University of Alberta

A Test of Non-metrical Analysis as Applied to the 'Beaker Problem'.

by

Natasha Grace Bartels

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Arts.

Department of Anthropology

Edmonton, Alberta

Fall, 1998

National Library of Canada
Acquisitions and Bibliographic Services
395 Wellington Street
Ottawa ON K1A 0N4
Canada

Bibliothèque nationale du Canada
Acquisitions et services bibliographiques
395, rue Wellington
Ottawa ON K1A 0N4
Canada

Your file Votre référence

Our file Notre référence

The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

L'auteur a accordé une licence non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de cette thèse sous la forme de microfiche/film, de reproduction sur papier ou sur format électronique.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author's permission.

L'auteur conserve la propriété du droit d'auteur qui protège cette thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

0-612-34298-0

Canada

University of Alberta

Library Release Form

Name of Author: Natasha Grace Bartels

Title of Thesis: A Test of Non-metrical Analysis as Applied to the 'Beaker Problem'.

Degree: Master of Arts

Year this Degree Granted: 1998

Permission is hereby granted to the University of Alberta Library to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly, or scientific research purposes only.

The author reserves all other publication and other rights in association with the copyright in the thesis, and except as hereinbefore provided, neither the thesis nor any substantial portion thereof may be printed or otherwise reproduced in any material form whatever without the author's prior written permission.

Natasha Bartels

70 East Valley Rd.
Corner Brook, NF.
A2H 2L5

May 15, 1998

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A Test of Non-metrical Analysis as Applied to the 'Beaker Problem' by Natasha Grace Bartels in partial fulfillment of the requirements for the degree of Master of Arts

Pamela Willoughby

Owen Beattie

Nancy Lovell

John Langdon

Abstract

The aim of this study is to test the effectiveness of non-metrical skeletal analysis as a research tool for establishing prehistoric population change. This research method is based on the comparison of frequencies of non-metric skeletal traits between populations. The case used for this study is the supposed advent of the 'Beaker culture' in Britain at the beginning of the Bronze Age. The Beakers (named for their distinctive pottery vessels or Bell Beakers), were first identified in the late 19th century, and were assumed to be a distinct migrant population appearing in Britain at 2600 cal BC, bringing with them new farming techniques, mortuary practices, copper-working skills, and other cultural innovations (Harrison 1980). Recently this view has been challenged, and it has been suggested that cultural diffusion rather than population replacement led to this cultural change. The question of the identity, origins, or the existence of a distinct Beaker culture remains controversial (Burgess 1980; Brodie 1994).The findings of this study suggest that there was significant population change in the geographical areas tested, and that the Beakers may have been a distinct and migratory population. This suggests that migration or invasion, as well as cultural diffusion, may have led to the apparent cultural change at the beginning of the Bronze Age.

Dedication

This is dedicated to my parents, Alice and Dennis Bartels.

Acknowledgment

I would like to thank the following for their help in completing this project. Firstly my advisor Dr. Pamela Willoughby and my Committee. My friend Rebeccah Bornemann, the Holden family, the University of Alberta Population Research Laboratory, Dr. Dwight Harley, Dr. Mary Jackes and the staff of the following museums: the British Museum of Natural History, the curator of the Duckworth Collection at Cambridge University, the Hull City Museum, Sheffield Public Museum, Wells City Museum, the Devizes Museum and the Salisbury Museum.

Table of Contents

		Page
Chapter 1	**Introduction**	
Introduction		1
Skeletal Samples Used in Study		2
Population Samples and Locations		4
The 'Beaker Problem'		8
A 'Classic' Beaker Grave		10
Changes in Archaeological Theory and Beaker Studies		11
Nineteenth Century Archaeological Theory		11
Definitions of Archaeological Culture		17
Theories of Beaker Origins		20
Ceramic Theory in Archaeology		25
Rejection of Migration Theory		29
Beaker Presence in Britain a Unique Phenomenon		32
Present Trends in Archaeological Theory and the Beakers		33
Summary of Changes in Archaeological Theory		34
Early Use of Physical Anthropological Methods		35
Round vs. Long Head		36
'Plasticity' of the Human Skeleton		37
Recent Studies Based on Metrical Analysis		38

Chapter 2 Materials and Methods Page

Alternative Methods in Physical Anthropology: Post Cranial and Dental Non-metrics	41
Cranial Non-metric Traits and Population Affinity	44
Racism, Polygenesis and Non-metrical Analysis	45
Genetic Mechanisms of Non-metric Traits	48
Animal Studies on Non-metric Traits	53
Non-metrical Analysis Applied to Human Population Studies	54
Challenges to the Use of Non-metrical Analysis	57
Inter and Intra-observer Error	58
Potential Impact of Factors of Sex and Age on Non-metric Trait Expression	59
Potential Impact of Age on Non-metric Trait Expression	62
Potential for Inter-trait Correlation	63
Bilateral Trait Expression	65
Testing Traits for Sex and Side Correlation	67
Criticisms of Non-metrical Analysis	71
Purpose and Method of Study	74
Statistical Methods for Archaeological Samples	75
Stabilizing Trait Variance	75
Mean Measure of Divergence	76
Significance of Results	77
Problems with Collection of Data	78
Skeletal Samples Used in Study	79
Population Samples and Locations	81

Chapter 3 **Results** **Page**

Introduction to Results 84

Biological Distance 88

Discussion of MMD Analysis 89

Chapter 4 **Discussion and Conclusion**

Discussion 90

Conclusion 96

Alternative Methods of Study 97

Alternative Cranial Non-metrical Studies and Future Directions 99

Appendix A 100

Appendix B 108

References 113

Tables		Page
Table 1.1	Sample Location and Size	6
Table 1.2	Sex Distribution of Skeletons	6
Table 2.1	Sex Significant Traits	61
Table 2.2	Side Significant Traits	70
Table 2.3	Sample Size and Location	83
Table 2.4	Sex Distribution of Skeletons	83
Table 3.1	Traits Observed on Summed Sides	85
Table 3.2	Percentage of Trait Expression per Population	87
Table 3.3	Standard Deviations of the MMD Scores	88
Table 3.4	MMD Scores	88
Figure 1.1	Map of Sample Locations	7
Figure 2.1	Trait Liability	51

Chapter One

INTRODUCTION

Introduction

The purpose of this study is to examine the issue of population transition in prehistoric Britain. It is based on one aspect of physical anthropology, non-metrical analysis, the comparison of frequencies of the expression of certain skeletal traits between populations. This type of analysis may be used to attempt to establish the possibility of replacement, continuity or admixture in ancient populations. The debate regarding replacement vs. continuity is ongoing in archaeology and physical anthropology. It is reflected in numerous issues, ranging from the study of human origins and evolution, to comparatively recent human prehistory (Coon 1962; Lewin 1993; Rouse 1986). This particular study examines the question of continuity vs. replacement in regard to the so-called 'Beaker People'. This is a culture which apparently appeared throughout Central and Western Europe at the end of the Neolithic and marks the beginnings of the Bronze Age. When this culture came to be identified in the late 19th century, it gained much attention from archaeologists, and a great deal of debate grew out of questions as to the origins and movement of the so-called 'Beaker Culture' (Childe 1929, 1950; Harrison 1980; Brodie 1994).

This study involves the analysis and comparison of four populations separated by time and geographic location: these populations are classified as 1)Northern Early Neolithic, 2) Northern Early Bronze Age, 3) Southern Early Neolithic, 4) Southern Early Bronze Age. The populations named as Early Bronze Age are potentially Beaker peoples.

Through comparing non-metric trait frequencies between these separate populations, it may be possible to draw conclusions about the possibility of population replacement versus continuity.

Skeletal Samples Used in Study:

The majority of the skulls used in this study were originally excavated and collected in the mid to late 19th and early 20th centuries, prior to the development of radiometric dating methods, such as C_{14}. As a result, they were generally identified and dated by their archaeological context, stratigraphy, associated artifacts and mortuary practices. A number of the skulls were collected by well-known archaeologists of the day, such as Lord Pitt-Rivers, John Thurman and EJH Schuster. As a result they were studied and analysed according to the highest standards of the time. Reports detailing the archaeological excavations and stratigraphy were prepared and published. These reports contained illustrated descriptions of associated artifacts , the archaeological context and the skeletal remains found. As a result of the intense interest in metrical analysis at the time (See Chapter 2 for more details), many of the skulls and some post-cranial bones were measured and drawn (later photographed), in an effort to establish the population to which they belonged.

Other skeletal material used in this study was collected and analysed by various local amateur archaeological societies, such as the Wiltshire Archaeological Society. These societies were generally affiliated with a local museum and worked to excavate and

catalogue sites in their region. Members of these societies would undertake these excavations themselves, or would sponsor others to do so. Reports were prepared on the findings of these excavations and presented before the society and sometimes published in local journals. These reports contain details and illustrations of the excavations, archaeological contexts, associated artifacts and skeletal remains and are reputable archaeological sources for the time.

The materials I used in this study were held at the following museums: The British Museum of Natural History in London, The Duckworth Collection at Cambridge University, The Hull City Museum, Sheffield Public Museum, Wells City Museum, The Devizes Museum and The Salisbury Museum. Those I classified as 'Southern' all came from counties located in southern England: Dorset, Gloucesteshire, Northamptonshire, Kent and Wiltshire. The 'Northern' materials came from the counties of Derbyshire, Staffordshire and Yorkshire. (See Figure 1.1). I made this division for the purpose of creating contemporary populations made up of samples which were relatively close to each other. A number of the samples within these divisions are widely separated (up to 60 miles). Given the extremely sparse samples available in these time periods (Early Neolithic and Early Bronze Age), however, I felt this to be the only possible method of population comparison.

Within the categories of Northern and Southern, I compared Early Neolithic to Early Bronze Age. I would have preferred to compare populations over a smaller time range, such as Late Neolithic to Early Bronze Age, but this was not possible as there was very little identified Late Neolithic skeletal material in the areas containing Early Bronze Age,

Beaker material. All the non-metric observations were performed by myself, and not taken from secondary sources. Details of the individual skeletons used in this study, the museums they are held in, their associated artifacts, descriptions of their mortuary style and their references are given in Appendix A.

Population Samples and Locations

As mentioned previously, this study makes use of non-metric analysis (See Appendix B for trait descriptions), in looking at the question of possible population change in the Neolithic/Bronze Age transition. While non-metric analysis has been widely used in various archaeological problems involving questions of population change in prehistory, it has not been a major research tool in looking at the so-called 'Beaker Problem' in Britain. This is in large part due to the lack of popularity of non-metric analysis in Britain.

In this study, four populations separated by location and time are compared (see Table 2.3 below), for descriptions of skeletal material and associated artifacts see Appendix A. The majority of the skeletons used for this study were male, see Table 2.4 for the sex distribution of the different population samples.

Population A: a population composed of samples taken from locations in the north of England from the Early Neolithic time period.

Locations and Sample sizes:

Yorkshire: Dinnington (11), Ebberston (2), Rudstone (2)
Staffordshire: Long Low (1)

Population B: a population composed of samples taken from locations in the north of England from the Early Bronze time period. These samples were associated with 'Beaker' vessels.

Locations and Sample sizes:

Yorkshire: Acklam Wold (1), Hanging Grimston (1), Garrowby Wold (1), Garton Slack (5), Towthorpe (1), Weaverthorpe (1), Rudstone (1)
Derbyshire: Green Low (1), Castern (1), Bee Low (1), Stakor Hill (1), Blake Low (1), Haddon Field (1), Monsal Dale (1), Mouse Low (1)

Population C: a population composed of samples taken from locations in the south of England from the Early Neolithic time period.

Locations and Sample sizes:

Dorset: Handley (4)
Gloucestershire: Belas Knap (5), Nympsfield (1), Rodmarton (2)
Kent: Coldrum (1)
Somerset: Chewton Mendip (1)
Wiltshire: West Kennet (8), Lan Hill (3), Norton Bavant (4), Lugbury (2), Heytesbury (2), Fussell's Lodge (1)

Population D: a population composed of samples taken from locations in the south of England from the Early Bronze time period. These samples were associated with 'Beaker' vessels.

Locations and Sample sizes:

Dorset: Gibb's Walk (1), Handley (2), Easton Down (1), Chrichel Down (1), Dorchester (1)
Northhamptonshire: Aldwincle (2)
Somerset: Chewton Plain (2)
Wiltshire: Stonehenge (1), Amesbury (2), Roundway (1)

Table 1.1: Sample Location and Size

Site Location	Total (n)
Northern: Early Neolithic (A)	16
Northern: Early Bronze Age (B)	19
Southern: Early Neolithic (C)	34
Southern: Early Bronze Age (D)	14
Total:	83

Table 1.2 Sex Distribution of Skeletons:

Site Location	Male (n)	Female (n)	Total (n)
Northern: Early Neolithic (A)	10	6	16
Northern: Early Bronze Age (B)	13	6	19
Southern: Early Neolithic (C)	23	11	34
Southern: Early Bronze Age (D)	13	1	14
Total:	59	24	83

Figure 1.1

Map of Britain, locations of Northern samples marked (*), locations of Southern samples marked (+).

*1	Derbyshire
*2	Staffordshire
*3	Yorkshire
+1	Dorset
+2	Gloucestershire
+3	Kent
+4	Northamptonshire
+5	Wiltshire

(After Harrison 1980:53).

The 'Beaker Problem'

The questions raised in the Beaker debate combine issues and concepts from the fields of physical anthropology and archaeology. These included the definition of populations, culture and cultural change, and the question of what constitutes cultural change and how it may or may not be revealed in the archaeological record. These are still highly charged questions in archaeology.

Physical anthropology addresses such questions using the physical remains of prehistoric people. It uses various techniques such as the recording of skeletal traits in order to identify distinct populations in prehistory and measure changes between and within these populations. Although what exactly constitutes cultural change in prehistory is controversial, it is clear that in various times and places there is a distinct and sometimes abrupt change in the material remains of a culture. This may be evidenced in a number of ways, such as the appearance of a new type of technology or a significantly different pottery or mortuary style (Childe 1950; Rouse 1986; Thomas 1991).

When such dramatic changes seem to appear abruptly, in the archaeological record, the question of what led to such change is raised. Was this change brought about by various internal factors or by the diffusion of a new idea or technique through trade or interaction with various other cultures? In the latter case the same population would be maintained or would have only undergone slight admixture. Or were these changes brought about through the movement of larger groups of people as a result of migration or invasion? This would result in greater changes to the local population such as outright population replacement or significant admixture. It is in questions such as these that

elements from both archaeology and physical anthropology are necessary research tools. Archaeology has attempted to define culture, cultural boundaries and cultural change. Physical anthropology is used to establish whether actual physical change has taken place in the population which may also have undergone significant cultural change.

The so-called 'Beaker problem' is an example of these types of issues. The concept of a supposedly pan-European ancient culture, the Beaker culture, first developed in the late nineteenth century. It began with the discovery of a number of single burial, mound-style graves across Western and Central Europe. These graves contained a distinctive type of ceramic vessel, wide-mouthed and decorated with complex geometric designs. These pots came to be called Bell Beakers by 19th century archaeologists, who felt they resembled inverted bells. Lord Ambercromby, founder of the Chair of Prehistoric Archaeology at the University of Edinburgh, popularized this name in the late 19th and early 20th centuries, with the publication of his illustrated study on these pots in 1912 (Harrison 1980:9).

Along with these distinctive pots, many of these graves contained a number of other items such as copper knives, flint arrowheads with barbs and tangs, stone wrist guards and ornaments made of sheet gold, amber, jet and bone. Archaeologists assumed these to be ritual items (Harrsion 1980:9).

A 'Classic' Beaker Grave

Beaker graves display a great deal of regional variety, and generally do not conform to a clearly recognizable pattern. There are, however, generally a number of assumed

'ritual items' which accompany the distinctive Beaker vessel. A 'classic' Beaker grave is described below:

> ..... the inhumation of a single individual, crouched or flexed and lying on one side. Grave goods generally include the Beaker pot itself, and sometimes one or more other items drawn from a fairly standardised repertoire. A good example of such a burial is Hemp Knoll in north Wiltshire. Here, a grave pit 2.4 x 2 metres, and the turf stripped from the surrounding area. The grave itself formed the focus for a small round barrow thrown up on the site once the burial had been made. A body of a male individual aged 35-45 was placed tightly flexed inside a coffin 1.75 metres long, possibly of wickerwork. A European Bell Beaker was at its feet, an archer's wristguard on the left wrist, and a bone toggle at the waist, perhaps attached to a belt. Outside the coffin but within the grave pit were a time of antler and usually, the head and hooves of an ox (Robertson-Mackay 1980).

Due to the discovery of the distinct Beaker pots and generally associated artifacts, many archaeologists at the turn of the century came to identify the occupants of these graves as part of a culture which spread though Europe during the late Neolithic (Harrison 1980:9).

> The early recognition of these assemblages was made easier by the distinctive style of the Bell Beaker pottery. Gradually, as more burials and their pots came to light all over Western and Central Europe, it seemed appropriate to refer to it as a culture, and speculation began upon the origins and significance of this material (Harrison 1980:9).

In this way, the so-called 'Beaker culture' first became the subject of much debate in the late 19th and early 20th centuries. As a result of this relatively 'long term' debate in archaeology, it is necessary to review how the treatment of Beaker skeletal and archaeological remains has varied over time. It is also necessary to consider the changes that have taken place in archaeological theory and the impact these changes have had on the analysis and interpretation of these remains.

Changes in Archaeological Theory and Beaker Studies

The issue of the status of bell beakers and a Bell Beaker culture raises a number of problems. There is the question regarding its origins, and also its 'construction' by archaeologists and physical anthropologists from the time of its discovery in the late 19th century up to the present.

Until the 1970s it was thought that the Beaker culture spread over a large area of central and western Europe around 2600 cal BC[1] and persisted in most areas until 2000 calBC, although it had largely disappeared from central Europe by 2300 cal BC and lingered on in Britain until about 1800 cal BC (Brodie 1994:3). As the Beakers appeared to date from at least 2600 cal BC, they belonged in the realm of prehistory. Since it is based on the study of the frequently damaged and sparse material remains of cultures of the past- prehistoric research is subject to interpretations reflecting the social theory of the time. In this way, as various social theories changed, or were challenged, the archaeological interpretations of Beaker sites were also subject to change. As the Beakers came to first be identified in the 19th century, the contemporary archaeological discussion surrounding them reflected the ideology of the time.

Nineteenth Century Archaeological Theory

At the time of the first discovery and identification of the Beaker culture, the general

[1] These dates are 'recalibrated' according to Renfrew (1973). See page 31.

theoretical approach prevalent in anthropological and archaeological work was based heavily on the underlying concept of 'progressive stages of evolution'. This was applied both to the ideas of early human evolution and of human societal development, and stemmed from the work of Charles Darwin and other researchers.

In England, the work of E.B. Tylor was extremely influential, and for much of the late 19th century, anthropology in England was known as "Mr Tylor's science" (Bohannan and Glazer 1988:61-63). He was the first to develop a 'practical' definition of 'culture' which could be used by anthropologists and archaeologists: "Culture or Civilization, taken in its wide ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society" (Tylor 1871). Tylor's most influential work was his book *Primitive Culture*. One of the most important concepts in this work, which had a very strong and long-lasting impact on archaeological theory, was his belief that it is possible to 'reconstruct' past cultures through the careful study of those in the present. Tylor suggested that present cultures retain a number of "survivals" from earlier stages in their social evolution. As a result, anything which exists in a present-day culture which is non-functional may be seen as a "survival" of a practice which had been functional during a previous stage in that culture's development (Tylor 1871). The work of E.B. Tylor was extremely influential in 19th century England, since it reflected the underlying concepts and beliefs held in anthropology and archaeology at the time.

In the United States, the work of the anthropologist Lewis Henry Morgan on the "stages" of social evolution was very influential. According to Morgan (1877), every

human society, in the past and present, went through naturally ordered and progressive stages. Though not every society 'completed' its evolution, at least some ordered progression was inevitable. These stages were respectively, Lower, Middle and Upper Savagery and Barbarism followed by Civilization (Morgan 1877). Each state of existence had corresponding economic, political and social structures of increasing complexity (Bohannan and Glazer 1988:36). Morgan was greatly influenced by the work of Darwin, as were many social theorists of the second half of the 19th century. While Darwin's famous 1859 work The Origin of Species was based on the study of the processes of physiological evolution, many of the underlying concepts and implications were influential in many different academic fields. One of the most significant implications in his work was the concept of 'inevitable progress', which is reflected in Morgan's theory of social evolution. Darwin expressed this view in terms of 'natural selection': "natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress towards perfection" (Darwin 1958:449). This view came to influence much Western thinking, not only in terms of the past, but also in terms of the present.

Another 19th century social theorist, Herbert Spencer, was highly influential. It was he who first coined the phrase "survival of the fittest". He also believed that human society passed through different stages of progressive complexity. He likened his theories of societal evolution to organic development- i.e. the development of a more and more highly evolved organism, with increasingly specialized and complex structures of hierarchical importance (Spencer 1860, 1876). Unlike various other writers, however, Spencer did not believe that progressive societal complexity was inevitable for all human societies. He felt

that many of the non-western cultures encountered and colonized by the West in the 19th century were incapable of further social evolution. He saw them as static and 'frozen in time'. As a result of views such as this, it was believed that these groups could be used as models of earlier stages of human social development. In terms of the 19th century economic and political milieu, the colonizing, expansionist policies prevalent at the time could be justified as bringing 'civilization' and 'progress' to lesser-evolved societies. This was seen as a positive and natural process which was beneficial to the evolution of humanity at large (Harris 1968:134). Darwin was one proponent of this view, he claimed that 19th Century imperialism and colonialism were clear evidence supporting his belief in the inevitable upward evolutionary progress of both the biological evolution and humanity, and the social evolution and progress towards humanity's highest state, civilization. Darwin suggested that the fact that 'civilized' nations were supplanting 'barbarous' nations worldwide, was proof of the superior evolutionary state of those nations successfully dominating others. He claimed that colonization was evidence of 'natural selection' acting on an intellectual and societal level, and that it was the 'arts' of these superior cultures, such as superior technology, which led to their success. Darwin claimed that: "it is highly probable that with mankind the intellectual faculties have been gradually perfected through natural selection" (Darwin 1958:154).

The theories of social evolution made popular by Morgan, Darwin, Spencer, and others were used to justify contemporary Western colonial expansion, they were also applied to interpretations of the cultures of the past:

> All that we know about savages, or may infer from their traditions and from old monuments, the history of which is quite forgotten by the present inhabitants, shows that from the remotest times successful tribes have supplanted other tribes (Darwin 1958:154).

This idea of societal 'progress' involving the conquest of an 'inferior' culture by another culture advantaged with a superior social structure and technology, became highly influential in archaeological theory and interpretations of prehistory. The analysis of the Beaker culture was also affected by this theoretical approach. Most of the theories put forward concerning the origins and movements of the Beakers incorporated the idea of movement. These theories were based on the concepts of a physically distinct and mobile people. These 'invaders', possibly mounted on horseback, were supposed to have spread throughout prehistoric Europe, bringing with them copper-working skills and establishing a trading network. Their movement was seen as being extremely rapid, and this was used to account for the apparent lack of associated settlements of the 'Beaker Folk' (Harrison 1980:11).

Archaeological theories based on the concepts of migration, invasion and movement, which brought new and superior cultural practices and technologies, were particularly popular in the British archaeological school, possibly as a result of Britain's own history of successive invasions.

> ..... the British were keenly aware that England had been conquered and settled in turn by Romans, Saxons, Danes, and Normans. British archaeologists postulated that similar invasions had occurred in prehistoric times.... most historians argued that what was biologically and culturally most desirable in successive indigenous populations had combined with what was most advanced in invading groups to produce a people whose hybrid vigour, composed of various European stocks made them the best in the world (Rouse 1972:71-2).

This attitude was prevalent in the 19th and early to mid-20th centuries. As a result, British archaeologists in particular were predisposed to view the Beakers, and other prehistoric cultures, in terms of migration and invasion. External cultural forces, moving into Britain from continental Europe, brought with them cultural change and technological innovation.

The distribution of Beaker sites, however, did not correspond to any clear migration pattern. The reason for the confusion they raised was that early on in their discovery and identification, it was clear that the material remains of the so-called Beakers did not conform enough to reflect a clear-cut cultural identity. The graves that were assumed to be Beaker were spread widely across Western and Central Europe, with concentrations in certain areas, including parts of Britain. These graves did not leave a consistently recognizable pattern in the archaeological record. The Beaker graves found in Brittany were chambered tombs, while in Ireland they have been found in a wide variety of burial types. Those graves found in northern Britain were cist burials, while those graves found in the south were barrow burials. Beakers in Britain have also been found in association with both individual and multiple inhumations, as well as with cremations (Burgess 1976:311).

Along with this lack of a common Beaker grave type, there was also a clear absence of associated and consistently present material remains of daily life, i.e. dwelling types, particular farming or herding techniques, or various other identifiable common factors in daily life between the widely scattered Beaker graves. There was no evidence of a consistent economic or social system. Settlement and dwelling types varied, as did

mortuary and ritual monuments in different regions. Bell Beaker vessels have been found in many 'non-Beaker' archaeological contexts. Furthermore, while the earliest Beakers found appeared to display some uniformity in terms of general shape, style and decoration, the Beakers appeared to have been modified fairly quickly to reflect regional characteristics (Burgess 1976:309).

Definitions of Archaeological Culture

This lack of a consistent and recognizable 'cultural complex' led to problems regarding the definition of the Beakers as a distinct culture in prehistory. The assumption that the types of associated artifacts found within certain graves were the remnants of a distinct 'people', was based on an archaeological definition of 'culture'. This definition was applied to the so-called 'Beaker Folk' and other supposed extinct ancient peoples by V.G. Childe- one of the most influential voices in archaeology in the first half of the 20th century. He defined the concept of archaeological culture as follows:

> We find certain types of remains- pots, implements, ornaments, burial rites, house forms- constantly recurring together. Such a complex of regularly associated traits we shall term a 'cultural group' or just a 'culture'.
> We assume that such a complex is the material expression of what would to-day be called a 'people' (Childe 1929:v-vi).

Childe's concept of 'culture' was heavily influenced by the work of Gustaf Kossina, a German archaeologist working in the late 19th and the first half of the 20th century (Trigger 1989:163-167). Kossina's work was extremely nationalistic and was later used by

the Nazi regime in Germany to justify its expansionist and racist policies. Despite Kossina's personal views and the later applications of his work, his novel approach to archaeology and the concept of archaeological culture was extremely important and influential.

Kossina claimed that the archaeological record of Europe from Upper Palaeolithic times onward could be broken down and organized into a mosaic of clearly recognizable cultural groups that altered over time in terms of location and content. Kossina firmly believed that culture reflected ethnicity or a group identity. He believed, as did many other archaeologists, that "cultural continuity reflected ethnic continuity", meaning that if the archaeological record reflected no significant change in the material remains of a culture, then it would indicate that the local population had remained stable. As a result, Kossina argued that it was possible by 'mapping' the distribution of the types of artifacts that appeared to be characteristic of specific tribal groups, it was possible to establish where these groups had lived at different periods in prehistory. He called this type of approach 'settlement archaeology' (*Siedlungsarchaologie*). Kossina believed that by identifying tribal groups found in historical references with archaeological cultures from the early historical period, it would be possible to identify and trace these cultural groups backwards in time archaeologically (Trigger 1989:165). Kossina's ideas were extremely important as he was "not only the first archaeologist to use the concept of the archaeological culture systematically but also the first to apply the direct historical approach to the study of a large region" (Trigger 1989:165). He relied on the identification of specific artifacts and artifact styles and types for the identification of a

distinct culture. Gordon Childe further developed this method. He based his work on a small number of 'diagnostic' artifacts. Childe believed that particular types of artifacts such as ornaments, home-made pottery and burial styles, were a reflection of local tastes and were therefor relatively resistant to change. As such, these artifacts and mortuary styles could be used to identify specific prehistoric ethnic groups (Trigger 1989:171).

The archaeological approach popularized by Childe was extremely influential and innovative. He not only refined Kossina's work on identifying distinct archaeological cultures through their material remains, but applied these methods to identifying the physical movement of populations in prehistory. Childe argued that if the same cultural 'complex' could be found with little apparent change over a wide geographic area, this might be an indication of the physical movement of a culture from one area to another (Childe 1929:vi). In this way, the concept of population movement resulting in cultural change was part of the foundation of archaeological cultural theory in the late 19th Century. This was reflected in the assumption that apparent cultural change, as seen in the archaeological record, is a result of the movement of groups of people, either through invasion or migration.

The idea that, left to themselves, cultures are naturally 'static' was widely accepted by the first half of the 20th century. Childe wrote,

> ...primitive communities today are extremely conservative. Not only do they seldom invent new processes, they will not even borrow a superior device from close neighbours when, as in the case of the plough, it would involve an extensive change of the established structure of society....In the past, too, I feel that cultural change, however well it corresponded to the changed needs of a society, was often effected only by a shock from without (Childe 1950: 10).

As a result of this underlying assumption in archaeological theory, the concept of 'movement' and 'external influence' was linked to the so-called Beaker culture from early on in its study. As mentioned earlier, however, the Beakers did not leave evidence to suggest a mass migration or invasion, which would have brought with it new cultural practices and a new population. Because the Beakers did not appear to exhibit a clearly uniform and recognizable culture, much debate surrounded them and a number of theories have been developed regarding their possible origins and movements. Because the remains of the Beakers did not indicate mass migration or invasion, the theories regarding their origins and movements were frequently based on the concept of 'diffusion'.

Childe expressed the fairly popular diffusionist perspective. He believed that major technological innovations such as the potter's wheel, efficient copper smelting, the wheeled cart or the scythe were generally made once and 'diffused' from a single centre. Childe believed this was a theoretical stance from which to work from in archaeological analyses (Childe 1950:9). The concept of diffusion became extremely influential in archaeological theory. It was in part a reaction against the earlier concepts put forward by Lewis Henry Morgan and others, of the ordered and inevitable evolution of cultures (Trigger 1989:152).

Theories of Beaker Origins

According to the diffusionists, the Beakers would have originated in one geographic area and migrated outward from this central point. Much work was done on establishing

the location of the Beakers' supposed point of origin. The various locations which had been suggested by the 1920s: the Orient, Egypt, Central Europe and Spain, were put forward primarily due to the fact that these areas were fairly exotic and little-known areas (Harrison 1980:13). At one time, the Iberian peninsula was seen as the most likely place of Beaker origin. This was suggested by the Spanish archaeologist Professor Pedro Bosch Gimpera at the University of Barcelona and his student Alberto del Castillo. In 1928 Castillo published a book containing illustrations of all the beaker vessels he could locate, and this became the standard work on the Beakers. The rapid, successful movement of the Beakers across Europe from their supposed Spanish homeland, was explained as deriving from their nomadic, pastoral economy and their knowledge of copper-working (Harrison 1980:14).

This idea was also problematic, and many, like Childe, accepted it only with the greatest reluctance: "I find this view quite incredible but having nothing better to offer I shall accept it" (Childe 1950: 76).

As mentioned earlier, the Beakers did not conform easily to the definition of a unitary culture, used by Childe and many other contemporary researchers. As a result, many different theories were put forward to explain the wide dispersal of Beaker graves and the lack of an accompanying consistent life style. Childe suggested the idea of a society of mobile, trading 'tinkers'. He argued that the Beakers could perhaps be regarded as armed traders. He compared them to the modern Arabs in Africa who travelled in search of merchandise rather than for land for settlement. Childe suggested that as a trading people, the Beakers could perhaps be credited with helping to establish regular trade routes

(Childe 1950:132). This idea was challenged when it was first put forward, as was the claim that the Beakers had originated in the Iberian Peninsula. The assumed Spanish origin of Beaker pottery was inadequate, as it failed to explain why such a large number of Beaker farmers would leave the Iberian peninsula in the first place and end up in such far-away places as northern Britain, Germany and Czechoslovakia (Harrison 1980:14).

In order to deal with these problems, Professor Sangmeister of the University of Freiburg, developed the 'flux-reflux' theory. According to Sangmeister (1972), the Beakers originated in the Iberian peninsula, but spread across Central and Western Europe in a 'flux' and 'reflux' movement, bringing with them new Central European forms of dress and metallurgy. Sangmeister claimed the reason behind these movements was the nomadic culture of these people. He likened them to the nomad smiths of Black Africa or the white peddlers in 18th century North America who traded gin and glass beads (Sangmeister 1972). Sangmeister provided only one of the many theories regarding the origins and movements of the Beakers. Burgess proposed that the Beakers moved as they were prospecting for metallic ores, and that they spread knowledge and techniques of metallurgy wherever they went. Burgess pointed out that during the period of the supposed migrations of the Beakers, the knowledge of metal working was reaching many parts of Europe. He believed that the discovery of metalworkers' tools in a number of Dutch Beaker grave sites, was proof of the link between a prehistoric quest for metals and the spread of the Beaker culture (Burgess 1976:312).

Yet another theory about the origins and movements of the Beakers was based on the assumed contents of the Beaker vessels being possibly what was traded. Sherratt proposed

that development and spread of alcohol was a key factor in the dispersal of the distinctive Beaker vessels and indicative of a change in the cultural practices across Europe from the 3rd millennium BC. He argued that the appearance of the Beaker assemblages across Europe at the start of the Bronze Age was an indication of the beginning of an important characteristic of European culture: male drinking rituals. Sherratt claimed that European cultures place great importance on alcohol-based hospitality, and that this could be broadly compared to other stimulants used in several other world cultures. He compared the European use of alcohol to the use of tea in China, coffee in Arabia, and chocolate in Mesoamerica. He claimed that alcohol was a particularly powerful social lubricant due to its intoxicating properties, and as a result could hold a central symbolic position in both secular and religious contexts. Sherratt claimed that while more than one type of drink might be involved, he believed that alcohol was a crucial common element in the cultural expansion of the Beakers across Europe at the beginning of the Bronze Age (Sherratt 1987:82).

This theory was further developed by Burgess (1976), who suggested that the mere presence of alcohol was not sufficient to explain the evident changes in cultures across Europe at this time, or the widespread appearance of the Beaker vessels. Instead he proposed that the spread of the Beaker vessel across Europe was the result of the development and spread of a cult which was based on the use of alcohol in combination with the distinctive Beaker vessel. Burgess suggested that the Beaker and its supposedly alcoholic contents were the key elements in a prestigious ceremony or cult that spread across Europe. He suggested that initially the ceremony would have been fairly simple, but

over time would have gained complexity as it was adapted to local traditions and took on an 'heroic ethos' or a 'warrior element' (Burgess 1976:311).

In order to show that a cult and its ceremonial accoutrements may spread over great distances and between different populations, Burgess made use of a modern example, that of the so-called Peyote cult. The Peyote cult had started among the Mexican Indians in the first half of the 19th century, but by the 1850s had spread to numerous tribes in the United States and crossed the border into Canada. The Peyote cult is based on the ritual consumption of the hallucinatory peyote cactus. The ceremony involved in this consumption makes use of a number of ritual items which have remained fairly standard throughout North America, despite some local embellishments and variations. Burgess held the Peyote cult up as an example of how an artifact assemblage could spread across large areas without the mechanisms of trade or migration. He suggested that the hypothetical Beaker 'cult' could have spread across Europe in a similar manner. Such a cult 'package', based on a ritual of beer-drinking and the use of ornately decorated, specialized pottery vessels, he argued, could be spread from group to group across Europe. This, he believe, could explain the degree of regionalisation of Beaker vessel styles, along with the more standardized 'functional' elements found at Beaker sites, the stone wristguards, tanged copper daggers, etc. Burgess claimed that these items offered less scope for modification to local craftsmen. It would also serve to explain how the Beakers appeared to fit so comfortably into such different regional contexts (Burgess 1976:312).

All of these theories of the origins and movements of the Beakers have been

seriously challenged at various times. Those theories based on the concept of the ceremonial use of alcohol and beaker vessels are questionable as no evidence of any alcoholic contents (such as malted barley grains) has been found within these vessels (Harrison 1980:9). All of these theories were based on the study of the material remains associated with the distinctive and highly decorated Beaker pottery vessels. It was these vessels which gave the 'Beaker Folk' their name, and the study of these vessels has held a place of great importance since the beginning of the so-called 'Beaker Problem'.

Ceramic Theory in Archaeology

The study and analysis of pottery has traditionally played a very important role in archaeological research. The primary reason for the importance awarded the study of ceramics in archaeological theory is that of the assumed 'stability' over time of pottery-making techniques in prehistoric societies. As a result of this assumed stability, any significant change in ceramic style, is seen as an indication of some type of change within a culture. The decoration of pottery, for example, was used as a measure of "style" or ethnicity: "archaeologists believe that ceramics can reflect the culture of a people such that the main forces of cultural change that affect a society are reflected in their ceramics" (Grieder 1975:850-1). This theory was applied to the study of ceramics in Britain: "In Neolithic Britain one of the most striking features of the ceramic sequence is the relative stability of ways of making and decorating pots over centuries or even millennia" (Thomas 1991:85). A deviation in this stability resulting in a change in ceramic style is considered to be representative of radical cultural change:

> Whatever the specific reasons for such stability, the presence of a group of relatively unchanging artefacts which functioned in a number of important spheres of human activity would have been directly involved in the continuity of social reproduction. If the shapes, sizes and decoration of pots had any specific meanings attributed to them, the constant cycle of ceramic production and use would serve to recreate those meanings and to locate them in highly repetitive social activities. Pottery is a social production rather than the strategic creation of a decontextualized intelligence, and would always be produced in relation to what had been made in the past. Without preconceived plans to that effect, then, pots would fix meaning in time (Thomas 1991:85).

The study of ceramics was one of the primary methods for establishing dates and chronologies for prehistoric societies both before, and after, the introduction of radiocarbon dating. Since ceramic styles changed over time, and were thought to stand for ethnicity, from the time of their first identification, various researchers tried to establish a clear chronology and relationship between the different types of Beaker vessels, and through this account for their origins and movements (Thurman 1871; Ambercromby 1912; Piggott 1963; Clarke 1970; Lanting and Van der Waals 1972; Case 1977). The earliest workers on the question of Beaker ceramic chronology used seriology and created a fairly simplistic and straightforward classification system (Case 1977:72). With the advent of radiocarbon dating, later works established that the earliest Beaker vessels were found in the Netherlands, thereby debunking the idea that the Iberian peninsula had been their original source (Harrison 1980:15). The Dutch researchers Lanting and van der Waals put forward a chronology for the development of Bell Beakers in the Netherlands from the earlier Corded Ware forms (Harrison 1980:16). Various researchers worked towards establishing a chronology of Beaker styles. A number of these researchers held that there had been 'three phases'of Beaker styles: Early, Middle, and Late. Humphrey

Case dated the Early phase from 2100-1950 BC, the Middle phase from 1950-1700 BC and the Late phase from 1700-1500 BC (1977:71).

Piggott summarized these styles in very simple terms as:

EARLY	Cord-Zoned
MIDDLE	Bell Barrel Short-Necked
LATE	Long-Necked

(Case 1977:72)

This was a very general and simplistic summary. Other researchers have used more complex systems of classification and detailed descriptions. Each of these systems, however, have been seriously challenged.

The theories based heavily on the study of ceramics have also been subject to changes in underlying assumptions and attitudes in archaeological thought. The earliest researchers relied on concepts of invasion and migration as an explanation for the seemingly abrupt appearance of Beaker vessels throughout Europe. A number of later researchers have based their theories on the concept of diffusion. They have moved away from the assumption that movement of people is necessary for cultural change, and increasingly accepted the idea of the movement of 'cultural ideas'. Beaker vessels in Britain have been viewed as 'intrusive' in ceramic theory. One of the reasons for this assumption is the fact that Beakers appeared abruptly in the archaeological record in Britain. They did not appear to have developed out of a previous style. Instead, they

appear to have had an abrupt introduction, relatively widespread use and a fairly rapid decline in popularity (Thomas 1991:85).

Recent ceramic theory, however, suggests that trade, rather than migration or invasion, was the primary factor in the movement of Beaker vessels into Britain. As mentioned earlier, the earliest Beakers found in Europe were apparently developed in the Netherlands from earlier pottery forms such as Corded ware and TRB antecedents (Lanting and van der Waals 1976). These early Beakers presumably became available in Britain through long-distance exchange ties. While later Beakers retained the same basic form over time, the Beakers manufactured in Britain rapidly developed local variations and their decoration came to reflect indigenous ceramic styles (Thomas 1991:101).

It has been suggested that the functional role of ceramics changed to a more ritualistic role over time, and that the Beaker vessels are examples of this. This has been argued firstly, that because of the small size of Beaker pots, their original interpretation as being drinking vessels might not be inaccurate. Secondly, Beaker vessels are generally found in mortuary sites and appear to be ritually associated with the dead. Beaker vessels are, in fact, the first type of pottery routinely found in individual burials in Britain. These uses of Beaker pots could suggest a shift in the role of pottery from being simply functional, or objects used to display symbols, to being something important, desirable and prestigious for itself. In this way, it was suggested that for a period of time the Beaker vessels which were such high quality and elaborately decorated, were used extensively as a material expression of personal prestige (Thomas 1991:101).

The Beaker vessels have been interpreted as being indicative of the social change and

restructuring assumed by a number of researchers to have been ongoing at the beginning of the Bronze Age:

> In short, Beaker pottery disrupted the material order of later Neolithic Britain. Beakers were conceptual anomalies which could move between different spheres of practice, and in so doing undermined their separation and exclusiveness. The social conditions which they ushered in were ones of confusion and contradiction, in which existing social tensions began to work themselves out. Consequently, the eventual effect was that new social and ritual discourses were able to become established (Thomas 1991:101-102).

Rejection of Migration Theory

The various theories put forward to explain the origins and identity of the Beakers, both in terms of population movement or cultural diffusion, proved generally unsatisfactory. These theories were widely questioned not only in terms of the Beakers, and the particular problems they raised, but also in terms of other issues and problems in archaeology. The idea that cultures could only change as the result of external factors by "a shock from without" (Childe 1950:10) began waning in popularity in the mid-1960's. The then 'younger prehistorians' began to reject the archaeological assumption that cultural change must result from invasion, migration, or even diffusion. These concepts became linked to the imperialist past, and the idea of internally fuelled cultural change began to gain acceptance. Grahame Clark, an archaeologist who concentrated on British archaeology, was one of the most well-known proponents of this view. He labelled the emphasis on migration and invasion in archaeological theory the "invasion neurosis". He claimed that this 'neurosis' was waning along with the imperial power it had been linked

to. British archaeologists, he argued, were beginning to acknowledge and value the achievements of their forbears, and to view those achievements as having indigenous origins, being "manifestations of an age-long process of organic growth" (Clark 1966:173).

Clark used the study of the development of pottery as proof that a great deal of the cultural change in Britain evident in the archaeological record was brought about by internal rather than external factors. Clark claimed that a change in ceramic style was not necessarily a result of an external influence, but could instead reflect internally produced cultural change. He used a type of ceramic style known as 'Peterborough Ware' to illustrate this. Peterborough Ware appeared in England without any apparent equivalent ceramic style in continental Europe. Clark therefore suggested that Peterborough Ware was developed within England from earlier styles (Clark 1966:175).

He did not suggest, however, that all cultural change in Britain was internally produced. He claimed that while there was clearly an initial wave of migration into Britain and numerous waves at later intervals, there were long periods of internal development and cultural change in between the movement of large groups of people. Clark felt that these long periods between various population influxes had been ignored by archaeologists. He acknowledged that the farming economy and the technological complex that made up Britain's Neolithic era were necessarily introduced from the European mainland, but he believed that once this complex had been introduced and farming communities established throughout Britain, these communities continued to develop their own traditions and cultural practices independently (Clark 1966:176).

Clark's claims of internally fuelled cultural development in Britain gained support through the discovery that the radiocarbon dates acquired after its first development were inaccurate. These dates were 'recalibrated'. This recalibration was applied to British archaeological sites and megalithic remains by Colin Renfrew. He established that these sites pre-dated those found in the Aegean and Middle East (Renfrew 1973). It had been claimed by a number of earlier researchers that diffusion from centres of 'higher culture' had led to the construction of these British monuments. Renfrew's work disproved these claims. Through this 'recalibration', Renfrew established a new 'long chronology' of British prehistory, and this sparked increased popular interest in Britains megalithic monuments. These were now being viewed as the construction of highly skilled prehistoric engineers and 'astronomer priests' (Trigger 1989:186).

The rejection of invasion theory assumptions are summarized in conclusion by Clark:

> To sum up, whereas for the first half of the 20th century it was common to try to explain every change in the culture of the first 3000 years or so of peasant culture of England in terms of invasion, the younger school of prehistorians has been more inclined to seek the explanation for change in terms of indigenous evolution. When, for instance, rich exotic things occur in the archaeological record, these are likely to be interpreted as signs of increasing wealth on the part of native leaders rather than as in themselves signs of replacement by an invading aristocracy. Invasions and minor intrusions have undoubtedly occurred, even if far less often than other forms of culture contact, but their existence has to be demonstrated, not assumed (Clark 1966:187-8).

Beaker Presence in Britain a Unique Phenomenon

Despite Clark's challenge of the concept of migration or invasion as the sole instigator of cultural change, he did not reject the idea that the Beaker culture was intrusive in Britain. He still believed that the appearance of Beaker pottery in Britain, in combination with numerous other cultural innovations, indicated an actual influx of people into Britain. Like earlier researchers, Clark believed that the brachycephalic skulls found in Beaker burials were proof of a different 'physical type' and therefore proof of a new intrusive ethnic group (Clark 1966:180).

The question of the origins of the Beakers in Britain was widely seen as an exceptional case by many of the archaeologists who were otherwise rejecting migration theory. This was due in large part to the fact that much of Britain's known history involved successive waves of invasion and external influence, and also to the simple fact that as an island, at some point external influence was necessarily inevitable. This is view is summarized by Burl:

> ....to the Beaker itself, a form of pottery and decoration unknown previously in the British Isles, and fired by an unprecedently skilful technique, has to be added the novel barbed and tanged arrowheads, the bracers, copper knives and small articles of gold, the emergence of a round headed people, a preference for single burial in flat graves or under very low round barrows, the deposition of grave goods, the brewing of beer, a knowledge of metalworking, the domestication of the horse and the herding of a smaller breed of cattle, *Bos longifrons*, unlike the bigger indigenous *Bos frontosus* of the British Neolithic (Burl 1987:110).

Present Trends in Archaeological Theory and the Beakers

More recent archaeologists have rejected both the 'invasion theory' and the assumption that cultural change in prehistory was necessarily the result of external factors. A number of researchers have suggested that the Beaker remains found in Britain are not necessarily intrusive elements, and have emphasized the indigenous role in cultural innovation and change and tend to view the introduction of Beakers in Britain as being a the result of a process of diffusion (Burgess 1980; Gibson 1982; Bradley 1984; Clarke et al 1985; Thomas 1991; Brodie 1994). The most influential work in terms of rejecting the concept of migration and the Beakers in Britain were the papers by Whittle (1981) and Burgess and Shennan (1976). They rejected migration for two main reasons summarized by Brodie as follows:

> 1) That the Beaker culture is not a culture as originally defined by Childe. It could not, therefore, be indicative of a distinct people, or folk.
>
> 2) That many of the non-material cultural novelties of the British early Bronze Age cultures did in fact have insular antecedents. They need not have been introduced by an immigration from the continent.
>
> (Brodie 1994:5).

A number of the researchers who rejected migration paradigms as explanations for the Beaker presence in Britain suggested instead that the distinctive Beaker vessels and associated artifacts were part of a 'diffusionary artifact package'. They suggested that the Beaker pots and other grave goods could be seen as objects associated with social status and rank. In this way, they would not indicate a distinct people or culture, but would instead reflect a change in social organization occurring during the Copper Age (2500-

2000 BC). At this time there was apparently a movement towards the concentration of wealth into the hands of a smaller segment of society, and a tendency towards a more stratified society. In this way, Beaker vessels and their associated artifacts could be viewed as status symbols among the elite (Harrison 1980:15). The diffusionary vector for the Beaker assemblages according to this view would have been elite-group interaction, and as a result "would have been adopted by indigenous communities and accommodated within pre-existing social formations, acting either as markers or as instruments of social change" (Brodie 1994:5).

Summary of Changes in Archaeological Theory

Archaeological theory has moved away from assumptions of migration or invasion as being necessary factors for cultural change. Many researchers have moved towards the ideas of 'diffusion of cultural ideas' through mechanisms such as trade to explain various changes in the archaeological record. Despite these changes in theory, the question of 'cause' in terms of the appearance of new cultural practices, technologies, mortuary practices remains, particularly when these changes appear to have been abrupt and fairly dramatic. Because of this, it is worthwhile to make use of techniques in the field of physical anthropology in order to determine whether population change has accompanied apparent cultural change. The use of physical anthropological techniques was present in the study of the Beakers from early on in their discovery.

Early Use of Physical Anthropological Methods

The early studies on the Beakers which were based on the analysis of their skeletal remains, were craniometric. These studies made use of various skeletal measurements, particularly of the cranium.

As mentioned earlier, the 'Beaker Problem' as it came to be called, exists due to the fact that the "Beakers" did not conform to the archaeological theory prevalent at the time of their discovery in the late 19th century. Their remains, both biological and archaeological, did not seem to reflect clear-cut migration patterns. Also, they did not seem to indicate a readily identifiable distinct culture. This was a result of the widespread grave sites which did not appear to have an accompanying recognizable cultural complex. Instead, the graves themselves seemed to be the only 'common factor' of the culture which was once assumed to have spread across Europe in the early Bronze Age (Harrison 1980; Brodie 1994). What increased interest in the Beakers in the late 19th century, however, and led to the growth of the assumption that they were distinct, was the fact that Beaker people appeared to be of a different physical type than those earlier populations in the same geographic areas. This resulted in various early studies which were applied to the so-called Beaker problem in attempts to establish whether the Beakers were actually a distinct 'people', and if they were, the nature of their origins and movements (Burgess 1976; Harrision 1980; Sherratt 1987; Brodie 1994).

In the late 19th and early 20th centuries, the field of physical anthropology was generally based on metrical analysis of skeletal material. This type of research made use of

measurements and proportional skeletal relationships. As mentioned earlier, a widespread assumption in the archaeological theory of the time was that a 'distinct culture' was inevitably linked to a physically distinct population. Moreover, it was believed that each distinct population would have a distinct material culture.

Round vs. Long Head

The Beakers appeared to lend themselves to this methodological approach. They seemed to be of a different stature than the earlier indigenous Neolithic populations, and more importantly, according to the assumptions of the time they appeared to have a different skull type than the Neolithic populations. The Beakers were Brachycephalic (round-headed) as opposed to the Neolithic populations which were generally Dolichocephalic (long-headed) (Harrison 1980:160). This was based on the 'cranial index', a ratio of the maximum width to the maximum length of the skull. "Relatively long skulls (ratio of .75 or less) were called dolichocephalic; relatively short skulls (over .8), brachycephalic." (Gould 1996:131-132). Many of the researchers using the methods of the time assumed this to be a clear indication of the presence of a distinct population.

> For a long time it was confidently believed that there actually was a physically separate group of people who made and used Bell Beaker pottery and the artefacts found with it. Early work suggested that the men in particular were above average height and more robust than was usual, and their skulls larger and rounder, especially when compared with the only other substantial number of skeletons of this period, recovered from megalithic tombs. If we combine the appearance of attractive pottery and a new technology with some skeletons which seem to be larger and better proportioned than their contemporaries, then it is easy to see how the 'Beaker Folk' came to take up such a durable position in the thinking of two or three generations of European prehistorians (Harrison 1980:159).

'Plasticity' of the Human Skeleton

Franz Boas was among those at the turn of the century, who challenged the important place of the cranial index in the field of physical anthropology, as well as the uses it had for social policy. He undertook a study between 1910-1913, which looked at the physical changes between immigrant parents and their American born children. Among the various differences he studied, was the cranial index ratio of skull width to length. Boas concluded that the cranial index is not necessarily stable between generations. "American-born descendants of immigrants differ in type from their foreign-born parents. The changes which occur among various European types are not all in the same direction. They develop in early childhood and persist through life" (Boas 1949:60). While there did not appear to be a definite trend towards either dolichocephaly or brachiocephaly among the children of immigrants born in America -among some populations the trend was towards roundheadedness, while among others it was towards longheadedness- it seemed that the cranial index, as well as other physical traits, were more 'plastic' and receptive to

environmental influences than had been assumed by earlier researchers. This was a particularly important and influential study, as it affected social policy regarding immigration (Gould 1996: 260-262).

Recent Studies Based on Metrical Analysis

Later researchers continued to challenge the assumption that the cranial index could be used as an indication of population distinctiveness in regard to prehistoric population change. One such researcher was Neil Brodie (1994). He made use of metrical analysis in looking at the 'Beaker Problem', and rejected the earlier conclusions that the 'roundheadedness' of the Beakers in Britain was a clear indication of their external origins. He suggested that a change in skull shape from long to roundheaded was ongoing in Britain during the early Bronze Age, the time of the supposed penetration of the Beakers into Britain. Brodie argued that if the brachycephalic skull type was characteristic of the Beakers, then following their migration, there should be a general trend towards brachycephalisation in that area. According to this view, areas which supposedly did not undergo settlement should not show a tendency towards brachycephalisation. Brodie found, however, that this was not the case. Instead Brodie found that the trend towards brachycephaly was found throughout north-west Europe in the late Neolithic and early Bronze Age. He believed that this was an indication that "cranial form is not genetically determined, and that it might alter through time by mechanisms other than those of microevolution" (Brodie 1994:71).

He based his claims on later studies of cranial index changes in Britain during times which underwent no major population change. Brodie found that the mean Cranial Index of the moderately dolichocephalic Anglo-Saxon-Scandinavian skulls, gradually increased over the early medieval period until a level of brachycephaly was reached that was nearly equivalent to the extreme brachycephalisation found in the British Bronze Age population. By the 17th Century, however, the mean Cranial Index had once again declined. These changes in the Cranial Index, which occurred during the historical period, were not accompanied by any major population influx. As a result, Brodie argued that factor other then genetics must have influenced these Cranial Index fluctuations (Brodie 1994:71).

Brodie went on to suggest that factors such as climate, as well as cultural change (such as increased tool development and use) might have led to changes in skull morphology in late Neolithic/early Bronze Age Britain (Brodie 1994:80). In this way, the early methods of research in physical anthropology which were used for studying the so-called 'Beaker Problem' and the question of population change in prehistoric Britain, were shown to be highly problematic. The use of a simple cranial index of width to length ratio was shown to be inadequate. This meant that a major part of the foundation for the argument that the supposed Beaker population in Britain had external origins, was removed.

If general physical type and skeletal proportions are 'plastic' and generally susceptible to environmental influence, then the question of what elements of the skeleton may be used as possible indicators of population change is raised. One research tool in physical anthropology which might be applied to the 'Beaker Problem' and to other questions of

prehistoric population change is non-metric analysis. This method is based on the study and comparison of small skeletal traits or markers which appear to vary between populations and seem at least in part, to result from genetic causes.

Chapter Two

Materials and Methods

Alternative Methods in Physical Anthropology: Post Cranial and Dental Non-metrics

There are various methods in physical anthropology which are used to attempt to establish population affinities. A number of these studies have been based on the study of non-metric traits on the post-cranial skeleton. Others are based on non-metrical dental analysis. The majority of the work which has been done on non-metrical methodology and analysis has been done on traits which appear on the cranium. As a number of problems with cranial non-metric traits have come to light, however, a number of researchers have tried to identify and analyze post-cranial non-metric traits (Angel 1964; Finnegan 1978; McWilliams 1974).

One such researcher is Michael Finnegan. He suggested that post-cranial skeletal traits might be of more use in archaeological population studies than cranial traits. He based this claim on several points: firstly, all the traits considered have the potential of bilateral expression- they may appear on either or both sides of the body, secondly, almost all of these traits tend to appear on the more robust segments of the skeleton, and are therefore more likely to be preserved. Thirdly, many of these traits have been studied and assessed for sexual dimorphism and side difference in terms of expression (Finnegan 1978:23). Finnegan undertook a study of the utility of post-cranial for population studies, using the Terry Collection held at the Smithsonian Institute. He tested 30 non-metric post-

cranial traits. He examined these traits on the basis of sex, side and age dependence.

His conclusions suggested that the factors of side and age dependency did not have a significant impact on the expression of these traits. He found that while there was some evidence of significance in terms of sex, he believed the statistical methods of assessing and treating these differences were sufficient to make these traits useful. Finnegan also studied some archaeological samples for this study, and concluded that it was possible to collect more non-metric data from the generally better-preserved, robust post-cranial skeletal material (Finnegan 1978:35). In this way, while limited work has been done on post-cranial non-metric traits, it seems they could provide useful data in archaeological studies on population change.

I did not make use of post-cranial analysis in this study, due to the fact that very few of the skeletons in this study had associated post-cranial bones. This is a reflection of the archaeological practices of the time of the excavation of these materials, in the late 19th and early 20th centuries. At this time, the skull was considered to be the most important part of the skeleton for the purpose of analysis (Thurman 1863-4; Rolleston 1877; Schuster 1905-6). As a result, often only the skull was collected and analyzed, and the post-cranial remains either discarded, or not identified with a particular cranium.

Non-metric analysis based on dental traits is another research tool which has been used to establish population distinctiveness and change. Researchers have found that tooth form is genetically determined to a high degree, and remains fairly stable from generation to generation in a given population (Turner 1989:88). As a result, dental non-metrical analysis has been used by a number of researchers to prove or disprove population

distinctiveness, and to establish migration patterns (Turner 1990, Irish 1990, Hanihara 1992).

Archaeological research based on dental non-metrics has a number of advantages. It has been shown that dental traits are less affected by environmental influences than other skeletal non-metric traits, this indicates that these traits are genetically determined to a large extent. There are a large number of dental traits which may be used, and they appear to be largely genetically independent of one another. Due to the heritability of these traits, many of them may be found in present-day populations, as well as in archaeological samples. This is extremely useful for the purpose of establishing continuity in population studies. The study of dental traits is also useful in terms of archaeological research, as teeth tend to be abundant and well-preserved in archaeological contexts and are not subject to the same degree of damage and distortion that other skeletal material frequently is (Lukacs 1984:23).

In terms of the material I used in my study, research based on dental non-metric trait analysis would be valuable, but also limited due to the condition of the material. Many of these samples were missing their mandibles and many of their teeth, due to the poor preservation and storage methods they had been subjected to.

Cranial Non-metric Traits and Population Affinity

For the purpose of my study I chose to use cranial non-metrical analysis. In order to explain my selection of this method, it is necessary to examine the history and background of cranial non-metrics as a method for establishing population change and distinctiveness.

The human skeleton has a number of identifiable minor traits or variants. Some examples of these traits are accessory zygomatic foramina, and coronal ossicles. There are over 200 recorded minor variants found on the human cranium and just under 200 variants found on the infra-cranial skeleton (Saunders 1989:95; Ossenberg 1969:702). These features have been given a number of names over the years. They have been called 'non-metrical' by some researchers, 'quasi-continuous' by others, and 'discontinuous' or 'discrete' by still others (Hauser and De Stefano 1989:1). The reason for this myriad of names is the ongoing debate about what causes these minor variants. Since this is still not fully understood, it is perhaps easiest to use the term 'non-metrical' or 'non-metric'. This name does not refer to the causes underlying these traits, but refers rather to the fact that they are generally recorded as present or absent, and are difficult or impossible to measure in any standardized way (Hauser and De Stefano 1989:1).

The history of the study of non-metric traits is long, beginning with the observations recorded by the ancient Greeks, as well as a number of early European anatomists, who viewed non-metric traits as curiosities. The systematic study and identification of non-metric traits and their potential significance, however, began in the early 19th Century (Saunders 1989:95). The organized study of non-metric traits was first used to support

the various 'theories of form', which were developed throughout the 19th century. One of the major ideas put forward in these theories was that "an organism passed through morphological stages of lower evolutionary forms during its development" (Prowse and Lovell 1995:105). This theory was proposed initially by Ernst Haeckel in 1866. He called it the 'biogenetic law', otherwise known as 'recapitulation'. This concept was based on the idea that 'ontogeny recapitulates phylogeny'. Coon explained this as follows: ".....each one of us, from fertilization to birth, passes successively through the forms of all his ancestors, being in turn amoeba, worm, fry, tadpole, and so on" (Coon 1968:164). The non-metric traits found retained in the fully developed skeleton were seen as the vestiges remaining from the evolutionary stages through which the organism had passed. This was known as the 'extreme recapitulation theory', according to which "the growth and development of form in the individual [was] a direct model for the evolution of life" (Saunders 1989:96).

Racism, Polygenesis and Non-metrical Analysis

Non-metric traits were also used as support for the polygenist theory which became popular in the 19th century. Polygenesis was in part a reaction against the concept of monogenesis, which was derived from Biblical interpretations. The concept of monogenesis was based on the biblical view of creation, the idea that all people were ultimately descended from a single source: Adam and Eve. In this way, the present-day human races were seen as products of degeneration from the perfection of Eden. Different

races were seen as having degenerated to different extents, blacks the most, and whites the least. The distinctiveness of the races was frequently explained as being the product of climate differences (Gould 1996:71).

The theory of separate racial origins or polygenesis gained in popularity throughout the 19th century, developing hand-in-hand with the growth of Western colonial expansion and dominance. It ranked the various 'races of man' hierarchically, with the western European 'whites' at the top of the scale: "The polygenist theory, which hierarchically ranked the living races of man, marshaled observations of the presence of skeletal variants (which appeared to be reversions to ancestral conditions) in certain of the "lowest" races, as evidence for racial primitiveness" (Saunders 1989:96). In this way, non-metric traits, seen as the last remaining vestiges of earlier, more 'primitive' evolutionary stages, were used to relegate the various 'races of man' to their lower places on the hierarchical scale. The more of these 'primitive' non-metric traits a particular population retained, the less evolved it was, and the lower the place it held on the scale.

As a result of World War II, and various other social and political developments, the hierarchical approach to human evolution and the study of 'race' declined and became less politically influential; but it did not entirely disappear. Some researchers used research on non-metric traits to support the views of Carleton Coon (1968). Coon's work may be seen as the 'last gasp' of the polygenist, hierarchical school of thought; he made use of skull measurements (i.e. cranial capacities), and 'primitive' traits, such as heavy brow ridges, etc. Coon believed that the 'races of man' were subspecies of humanity which he labeled: Australoid, Mongoloid, Caucasoid, Congoid and Capoid. He claimed that these subspecies

had been separated at some point in evolution (likely *Homo erectus*) and had continued to evolve at differing rates in their own locales. There had been enough gene flow to "preserve the unity of the species" but not enough to render these 'races' equal on an evolutionary scale (Coon 1968:4-5). Within the hierarchy of 'evolving races' which he developed, Coon placed Australian Aborigines at the bottom. He believed that the Aborigines had already been a 'marginal' people when they had been isolated in their 'archaic state'. Coon believed that some evolution was taking place, but that its overall rate was slow due to Australia being a 'marginal area' of the southern hemisphere. Coon justified his views by referring to the small crania capacities he had found in fairly modern female aborigine skulls of 930-956 cc. He claimed that as individuals had lived to maturity, this small cranial capacity was adequate to meet the needs of their culture, Coon held this up as proof that the Australian aborigines still retained a number of genetic traits which distinguished *Homo erectus* from *Homo sapiens*. This, he argued, reflected the fact that the rate of evolution differed in different parts of the world, and that these populations with different evolutionary rates could not be closely related to one another (Coon 1968:410-411).

Coon was fairly influential after WWII until the late 1960's, and a number of researchers accepted his views and worked from his standpoint. This is apparent in the work of Johan Torgersen who did work on non-metric trait frequencies in the 1940's and 50's. He made reference to Coon's theory of polygenesis in relation to his own study on the non-metric trait of "metopism".

Genetic Mechanisms of Non-metric Traits

Interest in non-metric analysis had declined along with the post-war fall in popularity of polygenist, hierarchical theories, and the recapitulation theory (Prowse and Lovell 1995:105). With the rise of the study of genetics, however, interest in the genetic mechanisms underlying the expression or absence of non-metric traits increased.

Torgersen worked on the genetic mechanisms and hereditary factors involved in non-metric traits such as the metopic suture, and various sutural bones (Torgersen 1951a, 1951b). He saw the genetic components behind the non-metric trait of the metopic suture as mechanisms of human evolution. Torgersen claimed that the characteristics of the metopic skull reflect trends in the evolution of the human skull. These trends being the thinning of the bones of the skull, the recession of facial prognothism, an increase in frontal curvature and an increase of the distance between the eyes. The later closure of the sutures of the skull, were, Torgersen believed, a trend in human evolution and also a trait of the metopic skull. He claimed that this genetic variability indicated the varying speed of the evolutionary transformation of the skull between different populations, and that the evolutionary trends reflected by the metopic skull had not yet started in the Australian aborigine population (Torgersen 1951a:200-201).

While this type of analysis is highly problematic by today's standards, Torgersen's work on the genetic components behind non-metric traits is still of interest because the causes of non-metric traits are still poorly understood. Torgersen studied non-metric traits such as the metopic suture and sutural bones extensively. He suggested that the metopic suture was inherited as a dominant trait, and that both inter-parietal bones and the metopic suture seem to be expressed at least in part as manifestations of the same hereditary

factors. He believed that the presence of inter-parietal bones may be the only phenotypic expression of these particular genes. Torgersen also suggested that there was evidence that certain gene action could delay the closure of skull sutures, as well influence the location of the growth centres of bone and the rate suture obliteration (Torgersen 1951b:382).

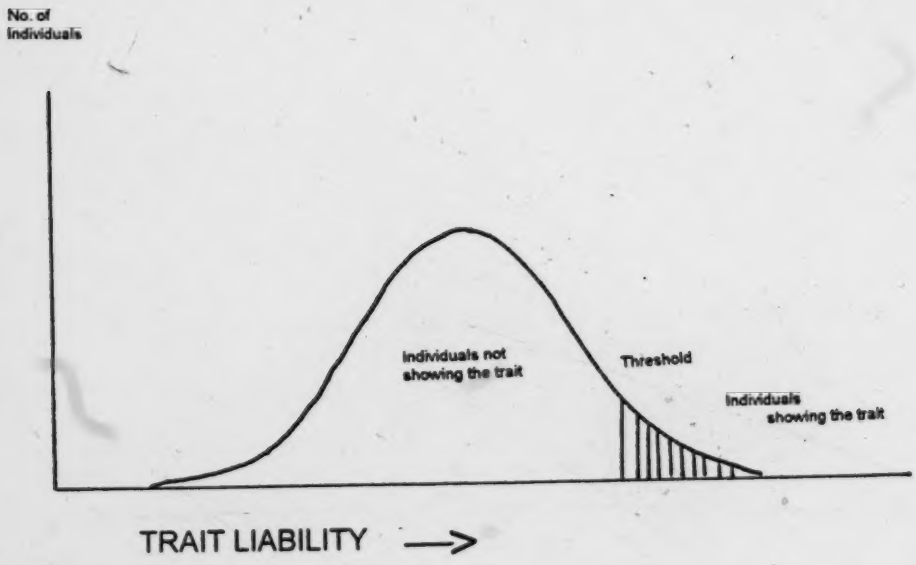
Torgersen also suggested that non-metric traits resulted from factors other than simple genetic causation:

> It is probable that the effect of these genes is influenced by the vascular supply. Considering the peculiar relationship between the pineal gland and the cranial sutures in some reptiles and amphibians, and the close topographical relationship of this structure to branches of the chorioideal arteries, the straight sinus and the vein of Galen, it seems probable that the pineal gland may be essential to the vascular mechanism; and by this means the genes affecting suture closure and the brain-skull correlation unfold their effect (Torgersen 1951b:381).

His work was significant in that he was attempting to establish a relationship between genetic factors and environmental influences in the expression of non-metric traits. This line of research has also been pursued by later researchers and has led to the beginning of 'epigenetic' studies. 'Epigenesis' may be defined as: "the process of progressive determination and differentiation of cells and tissues, as a result of the original genetic instructions operating in a progression of environments" (Hauser and De Stefano 1989:1). In other words, it is the interactions of environment(s) and genetics which result in the formation or expression of various non-metric traits. These traits have been called "threshold characters" based on the theoretical view that within a given population there is a varying 'liability' to manifest a particular trait. This 'liability' is reflective not only of an individual's genetic tendency towards expressing a particular trait, but also the other

environmental factors and various circumstances which could lead to the manifestation of that trait (Hauser and De Stefano 1989:4-5). This "threshold" is illustrated, see Figure 2.1 below.

Figure 2.1



(From Hauser and De Stefano 1989:5)

An individual within a population will develop a particular trait depending upon where he/she is in relation to this threshold. This model assumes normal distribution. The position of an individual within this distribution and in relation to the threshold is dependent on the genetic predisposition an individual has towards a particular trait. This can be called an individual's genetic 'loading'. In certain environmental conditions, an individual with sufficient genetic loading will manifest the trait. An individual with insufficient genetic loading in the same environmental setting will not manifest the trait. In this approach

> .....it is postulated that the genes are additive, equivalent in effect either positively or negatively, and of equal frequency. Superimposed on this genetic distribution is the influence of the environment (internal and external) in which the character develops (Hauser and De Stefano1989:6-7).

This indicates that the genetic factors behind non-metric traits are not caused by simple single-gene presence or absence, but result from a process of interaction between genetic factors and environmental influences. These relationships are still not fully understood: "the variants classified are the pleiotropic manifestations of many independent developmental processes, and that differences in the 'spectrum' of epigenetic variation between individuals reveals variation at a large number of gene loci" (Berry and Berry 1967:373).

Animal Studies on Non-metric Traits

Much of the work on the causes of epigenetic variation was done through population studies using mice. The researcher who is best known for these studies is Grunenberg who did much of his work in the early 1950's and 1960's (Saunders 1989:97; Berry and Berry 1967:362). Grunenberg and others did work on mouse populations because it is possible to carefully regulate and monitor genetic relations in mice from generation to generation. Grunenberg's work underlies the concept of the "threshold" in epigenetic theory. His work focused on a particular non-metric trait in mice, this being the presence or absence of the third molar. Grunenberg found that the third molar's development depended on the size of the underlying tooth germ. If the tooth germ is above a certain size the tooth develops; if it below this critical size, the tooth fails to develop. The size of the tooth germ is determined by a number of different factors: the genetic makeup of the individual and the genetic constitution of the mother. It is also influenced by the maternal environment (i.e. conditions within the womb), as well as pre-natal and post-natal environmental factors (Saunders 1989:97).

Grunenberg came to share the same conclusion which was suggested earlier by Torgersen, that the genetic factors involved were multiple genes with small, additive effects (Saunders 1989:97). Absence of the third molar occurred if the tooth germ still remained below the critical size five days after birth. In this way it became clear that the presence or absence of the third molar was dependent on size variations; therefore whatever factors influenced size had a direct impact on the presence/absence of this trait

(Saunders 1989:97). Grunenberg argued that the genetics underlying non-metric traits are complex and that the expression of these traits result from the action of multiple genes with additive effects. The liability towards the expression of a trait, according to Grunenberg, was continuous, but actual manifestation of the trait, was determined according to various threshold 'mechanisms', and is expressed in discrete categories (present/absent). Grunenberg labeled this type of variation in trait expression as 'quasi-continuous' because although the potential for trait expression is continuous, the action of threshold mechanisms for trait expression into discrete categories (Grunenberg 1963).

Non-metrical Analysis Applied to Human Population Studies

During the 1950's and 60's a number of animal studies were undertaken by various researchers in an attempt to understand the genetic and environmental factors leading to the presence/absence of non-metric or quasi-continuous traits within and between different breeding populations (Saunders 1989c:97). Interest in using non-metric traits to study human populations was revived by the 1967 study done by A.C. and R.J. Berry. In their study, the Berrys identified and illustrated thirty different non-metric traits on the human skull. They made use of these traits to determine whether the work done on mouse populations could be applied to human material:

> We undertook this study to determine the availability and extent of epigenetic variation in human material, and to test whether the multivariate statistical methods developed for use in the mouse can reasonably be applied to the analysis of human data (Berry and Berry 1967:363).

The Berrys studied 585 adult crania. These individuals came from a number of populations distanced from one another both geographically and temporally. The Berrys based their work on the idea that non-metric traits could be useful in identifying different human populations. They claimed that: "The frequency of any particular variant in a given race is constant, and is similar in related races. Indeed, geographical 'insoincidence lines' can be constructed for a variant in the same way that blood-group frequency maps can be drawn, i.e. as topographic maps of percentage frequency of occurrence" (Berry and Berry 1967:361).

The Berrys believed that the conclusions and findings from the mouse studies on epigenetic variation were applicable to human populations. They argued this on the basis that as epigenetic variants are an expression of the genes affecting development, there are differences in the incidences of these variants between populations. This, they argued, indicates genetical differences between populations and that these differences could be summed and used as "a measure of genetical distinctiveness or divergence between that pair of populations (Berry and Berry 1967:362). The Berrys went on to suggest that through these studies it was even possible to make deductions about past population movements (Berry and Berry 1967:362-3). They compared trait frequencies between populations in an attempt to establish population distinctiveness and the biological distance between populations.

As mentioned earlier, the Berrys made use of 30 non-metric traits which they generally recorded simply as present or absent. They did not make use of metrical analysis in their study, and they claimed that non-metric traits were of much greater use for looking

at questions of population identification and movement. They suggested that non-metric traits had the advantage over metrical analysis because non-metric traits were not affected by the age or sex of the individual, and that there were no inter-trait relations which affected their presence or absence:

> There is no doubt that epigenetic variant incidences have considerable advantages over morphological measurements for many anthropological purposes. In practical terms the lack of age, sex and inter-character correlations make the computation of multivariate statistics much simpler than is the case for metrical characters; scoring of variation is quick and easy; and there are grounds for believing that measures of divergence more accurately reflect genetical differences than statistics calculated from metrical data (Berry and Berry 1967:377).

The Berrys' article was extremely influential. Their claims of the advantages of non-metric traits over metrical analysis had a large impact, and a growing number of studies made use of the non-metric traits suggested by the Berrys. In their study, the Berrys had treated non-metric traits as superior to metric variables for the purpose of human population studies. They believed that the impact on trait frequencies of factors such as sex, side and inter-trait correlation, were minimal, and could be essentially disregarded. These claims, combined with the fact that traits could be scored on the often fragmentary bones in archaeological samples, made non-metrical analysis seem highly advantageous in terms of population studies based on archaeological samples. The Berrys (1967) claimed that the calculation of simple trait frequencies in skeletal samples could be used as "genetic markers", and that these could be used to assess the degree of biological variability between ancient populations. Because of the claims made by the Berrys, numerous archaeological population studies based on their trait list and statistical methods

were undertaken by various researchers (Saunders 1989:98).

Challenges to the Use of Non-metrical Analysis

The claims made by the Berrys, however, were soon disputed by other researchers. One of the most vocal and well-known researchers to challenge their assertions was Robert Corruccini (1974, 1976). Corruccini questioned many aspects of the usefulness of non-metric trait frequency studies. He began with challenging the concept of the dichotomous (present/absent) classification used for most of the non-metric traits suggested by the Berrys. He suggested that this classification system was not valid for looking at some traits. He pointed out that the research of Anderson showed that while the tubercle development in one population might be quite poor, the present/absent categories might still exist, but be harder to differentiate. As a result, there may be a different "threshold" for trait expression. Also, when faced with a sample of a population which has stronger tubercle development, this same observer might change his/her threshold value. In this way, Corruccini argued that intra-observer error was a serious potential problem in non-metric studies (Corruccini 1974:427).

Inter and Intra-observer Error

The issue of inter and intra-observer error, has been shown to be an issue in both metrical and non-metrical studies based on skeletal material (Utermohle 1982; De Stefano et. al. 1984). Non-metrical studies are based on the frequencies of traits scored as present or absent. Some non-metrical traits, however, may be expressed to a varying degree and these traits may recorded as "trace", "intermediate" and "present" (Corruccini 1974:427). As a result of the nature of the expression of non-metric traits and the scoring methods available, the issue of inter and intra-observer error must be taken into account.

A number of studies have been undertaken to determine the extent of observer error in non-metric studies (Saunders 1978; Molto 1979 and 1983; Buikstra 1972; Ossenberg 1974; Suchey 1975). These studies have shown that traits that may be partially manifested (those recorded as trace, intermediate and present) are subject to both inter and intra-observer error, and are therefore problematic.

In terms of cranial non-metric traits, researchers found that the identification of accessory foramina and traits which reflect the areas of attachment of tendons or ligaments are frequently subject to observer error. They found that the greatest error in post-cranial remains were those traits involving certain tubercles and tori, and those involving extensions of articular facets (Saunders 1978). In this way, observer error is an issue which should be considered in a study based on non-metrical analysis. As I was the only observer in this study, only intra-observer error was a potential problem. Ideally in this type of study, I should have re-scored a percentage of my samples and compared the

results. This could be used to give an indication of the extent of observer error in the study. Unfortunately, I was unable to perform this test of error due to limited time.

Potential Impact of Factors of Sex and Age on Trait Expression

For his study on the influence of sex and age on non-metric traits, Corruccini used the Terry Collection at the Smithsonian Museum because it is a large and well-documented, containing the skeletons of known individuals with accurate recordings of their respective ages and sexes. Thus Corruccini was able to examine the skeletons for various non-metric traits and use statistical analysis to see if there was any significant relationship between the age/sex of an individual and the manifestation of various non-metric traits.

Corruccini used more than the present/absent scoring system for non-metric traits in his study. He used both the dichotomous (present/absent) method developed by Berry and Berry (1967), as well as an ordinal method of scoring. This 'ranked' some of the traits in terms of extent of manifestation, i.e. "absent", "trace", "intermediate", and "present", as well as "double-presence" in the case of certain traits (Corruccini 1974:427). Corruccini also made use of more non-metric traits (61) than the Berrys. As a result of his sample sizes and the extensive information on the individual skeletons, Corruccini was able to run a number of comparisons which are generally impossible in the case of archaeological samples due to their small sizes. Among other things, Corruccini looked at sex differences between the 'races' (i.e. black and white) held in the Terry Collection. Corruccini

suggested that in their study the Berrys had ignored the possibility of variation in sexual dimorphism and non-metric traits between 'races':

> The purpose of testing sex variation is to determine whether males and females may be lumped into a reasonably homogeneous sample without distorting comparisons through combining different frequencies. The Berrys did not recognize the converse of this principle in aggregating racial samples of varying frequencies into two heterogeneous sex series. Sex variation over different samples could be canceled out by summing them (Corruccini 1974:428).

In terms of the differences between racial groups regarding non-metric trait differences resulting from sex differences, Corruccini found that a high proportion of traits were statistically significant in terms of sex difference. He also found that there was a difference in terms of race and sex-linked traits, and as a result of these findings, Corruccini recommended separate analysis for male and female samples in non-metric studies (Corruccini 1974).

Given the small sample sizes available in many archaeological studies, including this one, the separate analysis of the sexes is not possible. Instead, many researchers test each trait for sex-linked statistical significance. Only those traits which do not display significance are used in the study, and as a result, the sexes may be pooled. I used this method in my study, the test for sex significance was performed using a chi-square statistical test in the Microsoft Excel program. Seven traits displayed significance in terms of sex. The results of these tests are given in Table 2.1.

Table 2.1 Sex Significant Traits

Traits	Male		Female		X^2	P
	k / n	%	k / n	%		
Accessory Infraorbital Foramen	15/60	25.00	7/19	36.84	1.01	0.3160
Accessory Mental Foramen	10/67	14.93	1/20	5.00	1.37	0.2416
Auditory Torus	3/93	3.23	0/33	0.00	1.09	0.2968
Bregmatic Ossicle	2/57	3.51	0/24	0.00	0.86	0.3531
Condylar Facet Double	22/63	34.92	7/25	28.00	0.39	0.5330
Condylar Foramen	5/50	10.00	1/15	6.67	0.15	0.6953
Coronal Ossicles**	82/110	74.55	25/48	52.08	7.71	0.0059
Ethmoidal Foramen	9/66	13.64	0/24	0.00	3.64	0.0561
Frontal Foramen	40/118	33.90	11/42	26.19	0.85	0.3576
Frontal Grooves**	27/110	24.55	4/47	8.51	5.34	0.0208
Highest Nuchal Line	102/111	91.90	42/45	93.33	0.09	0.7594
Inferior Squamous Foramen	3/73	4.11	0/25	0.00	1.06	0.3037
Infraorbital suture	3/46	6.52	0/17	0.00	1.16	0.2811
Lateral Supraorbital Foramen	6/118	5.08	2/41	4.88	0.00	0.9588
Marginal Tubercle**	47/72	65.28	7/24	29.17	9.54	0.0025
Mastoid Foramen**	82/95	86.32	21/36	58.33	12.1	0.0008
Maxillary Torus	14/79	17.72	3/28	10.71	0.76	0.3837
Metopism	4/59	6.78	2/24	8.33	0.06	0.8044
Nasal Foramen	28/42	66.67	8/10	80.00	0.67	0.4118
Ossicle at Asterion	20/91	21.99	8/37	21.62	0.00	0.9651
Ossicle at Lambda	10/56	17.86	4/21	19.04	0.01	0.9044
Occipital Foramen	15/83	18.07	5/35	14.29	0.25	0.6161
Occipitomastoid Ossicle	17/93	18.28	3/36	8.33	1.96	0.1616
Parietal Foramen	53/107	49.53	20/47	42.55	0.64	0.4245
Parietal Notch Bone	15/92	16.30	8/37	21.62	0.51	0.4754
Patent Premaxillary Suture*	0/41	0.00	0/15	0.00	—	—
Posterior Condylar Canal Patent	25/42	48.08	6/17	35.29	0.85	0.3580
Precondylar Tubercle	6/34	17.65	1/14	7.14	0.88	0.3490
Rocker Jaw	6/32	18.75	2/10	20.00	0.01	0.9304
Squamomastoid Suture	25/92	27.17	5/34	14.71	2.13	0.1446
Squamous Ossicle**	10/74	13.51	8/26	30.77	3.88	0.0484
Supraorbital Foramen Complete	17/114	14.91	9/45	20.00	0.61	0.4346
Supranasal Suture	46/59	77.97	13/22	59.09	2.89	0.0889
Supratrochlear Notch	14/113	12.39	2/43	4.65	2.03	0.1546
Sutura Mendosa	41/88	46.60	12/34	35.29	1.27	0.2595
Sutural Foramen	31/89	34.83	12/37	32.43	0.07	0.7959
Trochlear Spurs	15/111	13.51	3/40	7.50	1.01	0.3147
Zygomatico-Facial Foramen**	45/75	60.00	22/26	84.62	5.24	0.0221
Zygomaxillary Tubercle**	41/68	60.3	6/22	27.27	7.26	0.0074

Table 2.1 Results of Chi-Square, testing the equality of trait incidence between males and females. Those traits which displayed significance based on sex are marked (**). Significance was determined using Pearson's Chi-Square. The trait marked (*) displayed 0% incidence and was discarded.

Where:

k is the number of observed traits

n is the total number of sides that the trait could have been observed in.

X^2 is Chi-Square statistic.

P is the probability of the result occurring, where P <= 0.05 is considered significant.

Potential Impact of Age on Non-metric Trait Expression

In his study, Corruccini also examined the effects of age on non-metric traits. The Berrys and those researchers who subscribed to their views, suggested that age had no significant effect on non-metric traits. Corruccini disputed this. He suggested that a number of the non-metric traits used in studies actually did appear to change according to the age of the individual, particularly: genial tubercles, trochlear spurs, inion salience, mastoid foramen, pterygoid foramen and postcondylar canals. While patterns of age dependence varied over different population samples, Corruccini found that "over twice as many age dependencies occur as can be explained by random error (Corruccini 1974:432). Corruccini also suggested that the effects of age have a varying impact on non-metric traits depending on the racial group: "Black females show greater age change than the others." In light of his findings, Corruccini claimed that "Age distances are comparable to sex distances in magnitude" (Corruccini 1974:432).

The analyses done at the time of the excavation of the samples used in this study, listed all of these remains as being adult, ranging generally between 30-60 years of age. The accuracy of these assumptions is debatable, given the difficulty in determining the age of adult skeletons:

> The accuracy with which postnatal age can be determined using traditional methods is inversely correlated with the age of the individual at death. In the younger age ranges, where estimates are based on developmental processes, more precise evaluations are possible. With older individuals degenerative changes are observed and accuracy drops (Reichs 1986:xix).

Moreover, the difficulty in determining age increases when dealing with the quality of skeletal material generally available in archaeological studies (Corruccini 1974:430).

There does seem to be an effect on a number of non-metric traits due to age. Those traits most affected are: genial tubercles, trochlear spurs, inion salience, mastoid foramen, pterygoid foramen and post condylar canals (Corruccini 1974:432). This is, however, not always consistent between samples, and a clear and systematic pattern listing those traits which are subject to the effects of age has yet to be developed.

Those studies which have examined age effects and trait expression, have generally found there to be a link between increased age and hyperostotic traits and lower age and hypostotic traits (Ossenberg 1969, Saunders 1978, Winder 1981, Molto 1983).

In the skeletal material I used for my study, I noticed that several of the skulls that had been identified as being over 60 years of age, had heavily ossified sutures. They had been almost completely obscured in parts. In these cases, the sutural ossicles present were no longer separate bones, but had 'melded' with the sutural lines. Where they were still observable (marked by a depressed line) I recorded them as present.

Potential for Inter-trait Correlation

Another claim made by the Berrys regarding the superiority of non-metric trait analysis over metrical analysis involved lack of inter-trait correlation. The Berrys suggested that due to the causes behind non-metric trait manifestation, various traits were fairly independent of each other in their expression. The reasons for this independence

would theoretically arise from their origin. If there is an underlying normally distributed liability for trait expression, and this liability is made up of numerous genetic and non-genetic factors, then the possible correlation between traits should be low (Saunders 1989:101).

Later studies using larger population sizes, however, tended to show some inter-trait correlation. It became evident that "non-metric traits may be correlated with one another if they follow common developmental pathways or are influenced by similar phenomena" (Saunders 1989:101). There does not seem to be a significant correlation between overall body size and incidence of non-metric traits. There does appear, however, to be a relationship between single or multiple non-metric traits and specific skeletal measurements. Several studies have suggested that there is a correlation between large bone size and hyperostotic traits (heavy bone development) and small bone size and hypostotic traits (light bone development)(Saunders 1989:101). While a number of other studies have concluded that both metric and non-metric traits result from the "growth and development of the soft tissues and functional spaces of the skeleton that act both locally and on a broader scale" (Saunders 1989:102).

In this way, it has been established that there is inter-trait correlation when the traits have a common underlying developmental pathway, or may be influenced by the same phenomena, such as environmental influences that have an impact on growth. Traits are also correlated when they are alternative expressions of a particular underlying variable (Saunders 1989:101). It has also been shown that certain environmental influences can affect particular non-metric traits in a similar way (Searle 1954; Dahinten and Pucciarelli

1983).

In looking at inter-trait correlations in human population studies, Sjovold (1977) found that when dealing with a large sample size- one involving hundreds of individuals, environmental and genetic intertrait correlations may be found. Few archaeological studies, however, involve sample sizes this large. Other researchers have found that intertrait correlations in human samples are fairly low and random (Berry and Berry 1967; Kellock and Parsons 1970; McWilliams 1974; Suchey 1975).

In view of the small sample sizes I was dealing with in my study, I chose not to test for inter-trait correlation.

Bilateral Trait Expression

One of the major questions raised by Corruccini (1974), involved "paired traits". Most non-metric traits exist on both sides of the body, e.g. accessory zygomatic foramen. After the publication of the Berrys' highly influential paper, a debate developed on how to treat non-metric traits which occur in pairs. Eventually two methods were widely accepted. The first method is based on the calculation of trait incidence by individual, i.e. number of individuals expressing the trait on one or both sides/ the total number of individuals. The second method is based on trait incidence by proportion of sides expressing the trait/ the total number of sides in the sample (Saunders 1989:98).

Both of these methods, however, assume that the expression of non-metric traits is independent between sides. The studies which have addressed this question, however,

show that there is, in fact, strong interdependence between sides in trait expression. The scoring and treatment of paired traits caused problems in the statistical analysis in various non-metric studies, particularly in those with small, damaged sample sizes (Saunders 1989:99). Measures have been taken to make statistical adjustments to deal with this problem. These techniques use side frequencies simultaneously but separately. These methods are still problematic, however, in that they fail to address the question of the cause of unilateral vs. bilateral trait expression.

Ossenberg suggested that the cause was a result of the genetic influences on the manifestation of non-metric traits. She suggested that the genetic "loading" for various traits increases the possibility of the trait being expressed bilaterally. McGrath (1984) and other researchers, however, suggested that this theory was at odds with the fundamental idea behind the "threshold" theory of non-metric trait expression: normal distribution. They argued, that if liability for graded trait expression is normally distributed, and influenced by multiple genetic and non-genetic factors, then there should be no mechanical or physical process that could influence trait expression in such a way as to cause the progression of unilateral to bilateral trait manifestation (Saunders 1989:99).

Several studies attempted to ascertain the causes for this asymmetrical expression of traits. The overall findings of these studies suggested that as non-metric traits are seen to result from the complex interaction between genetic and environmental factors, asymmetry in trait expression is caused by "random environmental disruptions occurring during development" (Saunders 1989:99). McGrath suggested that "non-metric trait asymmetry is due to fluctuating asymmetry". This is produced by "random nongenetic disruptions in

development that reflect the organism's level of developmental homostasis or ability to develop symmetrically" (McGrath 1984). If this is the actual cause of asymmetry in trait expression, it could be argued that recording and calculating trait frequency using either side, would be valid, as according to this view, fluctuating bilateral trait expression is totally random (Saunders 1989:99). This view, however, has not been definitively proven, and has not been widely accepted by researchers. Instead, it has been found that "bilaterally scored variants are not side independent, nor are they perfectly correlated" (Saunders 1989:98). As a result, it is necessary to test for interdependence of bilaterally traits in non-metric studies. In this study, side interdependence was tested by using the chi-square test in the Microsoft Excel program. The traits did not display significance on the basis of side. The results of this test are given in Table 2.2.

Testing Traits for Sex and Side Correlations

The non-metric trait frequencies were tested for sex and side correlation by using chi-squared statistical analysis. The chi-squared statistic is calculated on the basis of a two-by-two contingency table. These tables are set up as follows:

Contingency Tables for Sex and Side Analysis:

	Male	Female
Trait Present	a	b
Trait Absent	c	d

	Left	Right
Trait Present	a	b
Trait Absent	c	d

(after Green et al., 1979 and Mary Jackes, personal communication)

In order to establish possible significance in trait expression related to sex and side, Pearson's chi-square test was used. The p-value was considered significant at 0.05 In earlier studies, the standard rule has been that if one cell of a contingency table has a minimum expected frequency of less than 10, then Yates' correction for continuity is used. In the case of a cell containing a minimum expected frequency of less than 5, Fisher's exact test is used (Spiegel 1992:247; Sterling and Pollack 1968:298). More recent work, however, suggests that these corrections are unnecessary as long as the average cell frequency is 2 or greater (Glass and Hopkins 1996:335). As all the contingency tables for non-metric trait frequencies in this study contained average values greater than 2, the Pearson's chi-square test and associated p-values was used. The Microsoft Excel statistical program was used for these tests.

The chi-square statistic is calculated as follows:

$$X^2 = \frac{n(ad - bc)^2}{(a+b)(a+c)(b+d)(c+d)}$$

n= total sides observed (a+b+c+d)

(Green et al. 1979:630).

The results of the chi-square tests for sex and side are given in Tables 2.1 and 2.2. As shown in Table 2.2, none of the traits tested displayed significance on the basis of side. As a result of this, it was possible to pool the sides prior to testing for sex significance (see Table 2.1).

Table 2.2 Side Significant Traits

Traits	Left		Right		X^2	P
	k / n	%	k / n	%		
Accessory Infraorbital Foramen	9/41	21.95	13/38	34.21	1.48	0.2249
Accessory Mental Foramen	7/43	16.28	4/44	9.09	1.02	0.3136
Auditory Torus	1/66	1.51	2/60	3.33	0.45	0.5035
Bregmatic Ossicle	No side to side data					
Condylar Facet Double	18/44	40.90	11/44	25.00	2.52	0.1121
Condylar Foramen	5/33	15.15	1/32	3.13	2.80	0.0936
Coronal Ossicles	57/81	70.37	50/77	64.94	0.53	0.4651
Ethmoidal Foramen	4/45	8.89	5/45	11.11	0.12	0.7250
Frontal Foramen	31/80	38.75	20/80	25.00	3.48	0.0616
Frontal Grooves	17/83	20.48	14/74	18.92	0.06	0.8061
Highest Nuchal Line	74/78	94.87	70/78	89.74	1.44	0.2298
Inferior Squamous Foramen	1/49	2.04	2/49	4.08	0.34	0.5572
Infraorbital suture	0/31	0.00	3/32	9.38	3.05	0.0802
Lateral Supraorbital Foramen	2/80	2.50	6/79	7.59	2.16	0.1416
Marginal Tubercle	26/49	53.06	28/47	59.57	0.41	0.5199
Mastoid Foramen	58/70	82.86	45/61	73.77	1.60	0.2060
Maxillary Torus	10/54	18.52	7/53	13.21	0.56	0.4524
Metopism	No side to side data					
Nasal Foramen	No side to side data					
Occipital Foramen	10/66	15.15	10/63	15.87	0.01	0.9104
Occipitomastoid Ossicle	10/60	16.67	10/58	17.24	0.01	0.9342
Ossicle at Asterion	18/66	27.27	10/62	16.13	2.32	0.1273
Ossicle at Lambda	No side to side data					
Parietal Foramen	35/77	45.45	31/77	40.26	0.42	0.5146
Parietal Notch Bone	16/67	23.88	7/62	11.29	3.48	0.0615
Patent Premaxillary Suture	No side to side data					
Posterior Condylar Canal	16/34	47.06	20/35	57.14	0.12	0.7255
Precondylar Tubercle	No side to side data					
Rocker Jaw	No side to side data					
Squamomastoid Suture	18/67	26.87	12/59	20.34	0.74	0.3910
Squamous Ossicle	7/50	14.00	11/50	22.00	1.08	0.2983
Supraorbital Foramen	16/79	20.25	10/80	12.50	1.75	0.1865
Suranasal Suture	No side to side data					
Supertrochlear Notch	6/78	7.69	10/78	12.82	1.11	0.2916
Sutura Mendosa	25/61	40.98	28/61	45.90	0.30	0.5833
Sutural Foramen	26/65	40.00	17/61	27.87	2.06	0.1512
Trochlear Spurs	10/76	13.16	8/75	10.67	0.22	0.6362
Zygomatico-Facial Foramen	36/51	70.59	31/50	62.00	0.83	0.3615
Zygomaxillary Tubercle	25/50	50.00	22/40	55.00	0.22	0.6366

Table 2.2 Results of analyses testing the equality of trait incidence between the right and left sides. The traits were tested using Pearson's Chi-Square.

Where:

k is the number of observed traits

n is the total number of sides that the trait could have been observed in.

X^2 is Chi-Square statistic.

P is the probability of the result occurring, where $P <= 0.05$ is considered significant.

Criticisms of Non-metrical Analysis

This debate about the causes behind the asymmetrical expression of non-metric traits illustrates once again the fact that the causes underlying the manifestation of non-metric traits are still not fully understood. This uncertainty has been used by Corrinccini and his supporters to challenge the claim made by the Berrys that non-metric trait frequencies were of superior value for the study and analysis of archaeological skeletal samples. There were other serious criticisms of non-metric analysis, the methods which were used in non-metric studies, and the types of data collected.

> The most objectionable aspect of the discrete trait research model is the consideration that skeletal studies can be facilitated by the exclusion of all data but the most easily collected (i.e. discontinuous variants), and that further simplification may be attained through lumping all age, sex and trait categories as being inherently of equal value and meaning....Binary discrete trait analysis is probably the least desirable way to study skeletal population genetics (Corruccini 1974:440).

While Corruccini and others had harsh criticisms of non-metric analysis as a tool in archaeological research, they were also forced to acknowledge the overall difficulties in analysis of small, generally poorly preserved archaeological samples. Such samples are frequently badly damaged with only segments of the skeletons remaining. As a result, metrical analysis is also quite problematic. Accurate and complete measurements are frequently not available. Consequently, Corruccini and others did not propose a total abandonment of non-metric analysis as a tool in archaeological research. They suggested that while metrical analysis was a superior method for research purposes, non-metric

analysis and data could and should be used to supplement these data, to render as complete a picture as possible: "The pattern of quasi-continuous variation is irregular. Notwithstanding, its study can complete, though never replace, metric information" (Thoma 1981:309).

Corruccini suggested that within the acknowledged limitations of non-metric trait analysis, data that were collected correctly could be of use, and that both metric and non-metric studies could yield interpretable, genetically significant results, if treated in the same manner. That is if, as is done in metrical studies, the samples are analysed separately by sex, controlled for age discrepancies and the same numerical techniques are utilized. In this way, Corruccini suggested that non-metric analysis may provide valid data, as "when one treats non-metrical and metrical data in the same way, they apparently behave in much the same way" (Corruccini 1974:436).

It was also suggested by Corruccini and others that earlier studies involving non-metrical analysis had been badly flawed, and that more organized, systematic and in-depth studies might give a clearer picture as to the usefulness of non-metric data:

> Discrete cranial variants, while desirable as comparative data, have yet to prove themselves equally trustworthy [as metrical analysis]. It is clear that much more work is needed before non-metric traits can afford a basis for definitive statements about population relationships (Corruccini 1974:440).

Nancy Ossenberg also believes that non-metrics have not been developed effectively and that careful research could reveal more about their usefulness as a research tool. She argued that non-metric skeletal traits have been used successfully in animal studies, and that this indicates that non-metric variants could also be successfully used in human

population studies. She suggested that the use of different, carefully selected traits could be effective in such studies, and that "the unsatisfactory anthropological performance of the traits in some cases could be attributable to the particular set of variants used, rather than to this type [non-metric] of variant per se" (Ossenberg 1976:702). Ossenberg acknowledged that many specific non-metric traits are problematic, as there is evidence of dietary, pathogenic, functional or mechanical influence on the expression of certain non-metric traits. There may also be ambiguity in trait expression, which may make it difficult to establish standard criteria for scoring them, problems involving inter-trait correlations, and other factors such as sex and side significance, may cause inaccurate measures of divergence. Because of this, her work included an attempt to find some reliable and useful non-metric variants for the purpose of archaeological research (Ossenberg 1976:702).

Ossenberg concluded that she had identified a number of specific non-metric variants that were useful research tools in archaeological studies and that were valid when used along with other data: "I conclude that this battery of traits yields valid taxonomical information, and can be used in conjunction with other physical data to reconstruct the movements and affinities of extinct human populations" (Ossenberg 1976:708).

I suggest that while non-metric traits are problematic as a research tool in archaeological population studies, they are still useful. The types of traits being used must be considered carefully, as must the method of data collection. For example, it is important to determine whether a particular trait be recorded as simply present/absent, or with greater detail, such as ranked degree. Also, while non-metric traits are clearly not as useful (or superior) as the Berrys claimed, they are not to be completely dismissed in

favour of metrical analysis. As pointed out by the Berrys and others, metrical analysis is influenced greatly by environment, as well as by sex, race and other factors. As a result, metrical analysis as a research tool is also quite problematic.

Corruccini studied the impact of sex, age, race and intertrait correlation on non-metric traits (Corruccini 1974) using the Terry collection at the Smithsonian Institute. While this was an extremely important and ground-breaking study, it cannot be compared to the types of studies which are often necessitated by archaeological data. The Terry Collection is a massive, well-documented and well-preserved skeletal sample, while many archaeological skeletal samples are small and heavily damaged. Because of the very nature of such archaeological samples, whatever data may be collected from them is of use and should not be disregarded or dismissed. Clearly more work must be done to establish which non-metric traits are most useful in population studies based on such trait frequencies, and on the genetic factors underlying the manifestation of such traits.

Purpose and Method of Study

The aim of this comparison is to try to establish whether there was significant population replacement or admixture in the Early Bronze Age, at the time of the advent of the Beaker Culture. Non-metric variables were recorded and the percentages of trait frequencies from Population A were compared to those of Population B, and the percentages of trait frequencies for Population C were compared to those of Population D. I also compared Population A to Population C and Population B to Population D, in

order to see of these comparisons would indicate population replacement or continuity. These comparison will utilize the type of statistical analysis which has been developed for the specific use of archaeological research.

Statistical Methods for Archaeological Samples

In the last several decades the work done in skeletal analysis, both in terms of metric and non-metric data, has been greatly affected by a number of developments in statistical analysis techniques. The changes made in these techniques have worked towards improving the methods used in the analysis of the small and damaged skeletal samples which are often all that is available for archaeological research. In the case of this study, the statistical method used was aimed at establishing a measure of biological distance between populations. This method is known as the 'Mean Measure of Divergence' or the MMD. This formula was first used by Grewal in 1962, at the suggestion of C.A.B. Smith, in his paper on genetic divergence in mice (Green and Suchey 1976:61). In terms of human population studies, the MMD method was also utilized by Berry and Berry in their influential 1967 paper, "Epigenetic Variation in the Human Cranium."

Stabilizing Trait Variance

In order to perform this calculation, it is necessary to transform the percentages of the original trait frequencies. This transformation process serves to stabilize the variance of

the sample proportion. This transformation equation was developed by Freeman and Tukey (1950), and it has been found to be the most effective transformation in dealing with the small sample sizes generally available to archeologists (Green and Suchey 1976). It is performed for every trait for each population and this results in angular values which are denoted by Θ (theta) (Green and Suchey 1976:66).

The transformation equation is performed as follows:

$$\Theta = 1/2\sin^{-1}(1-2k/(n+1)) + 1/2\sin^{-1}(1-2(k+1)/(n+1)). \qquad 1$$

Where:

Θ = $\sin^{-1}(1-2k/n)$.

k = the number of times the trait occurs

n = the number of sides examined for the trait.

Mean Measure of Divergence

Once the Θ values are derived for each of the trait frequencies for each of the populations, they may be used in the MMD equation, which is used to establish biological distance between the populations being compared. This distance is described by Ossenberg as: "a statistic which expresses the sum or average of differences between two population samples with respect to *n* attributes" (Ossenberg 1976:704). The Mean Measure of Divergence (MMD) equation is performed as follows:

$$MMD = \sum_{i=1} ((\Theta_{1i}-\Theta_{2i})^2-((1/(n_{1i}+1/2)+1/(n_{2i}+1/2)))/t. \qquad 2$$

Where:

Θ_{1i} = the transformed proportion of one trait for the first population

Θ_{2i} = the transformed proportion of one trait for the second population

n_{1i} = the number of sides examined for one trait in the first population

n_{2i} = the number of sides examined for one trait in the second population

t = the number of traits considered

(Green and Suchey 1976:65-67)

Significance of Results

Significance of the results was determined using the method developed by J.A. Sofaer (1986:270). It is based on finding the standard deviation of MMD, which is calculated as follows:

$$Var_{MMD} = \frac{2}{r^2} \sum_{i=1}^{r} \left(1/(n_{1i} + {}^1/_2) + 1/(n_{2i} + {}^1/_2) \right)^2 \qquad 3$$

Where:

r = number of traits used in the comparison

n = the number of individuals scored for the trait in each population

Where:

$$^{sd}_{MMD} = \sqrt{Var_{MMD}} \qquad 4$$

The analysis in this study was performed using standardized MMD scores. This is considered necessary when, as is the case in this study, samples of different size are being compared. The standardized MMD scores were obtained by dividing each raw MMD score by its standard deviation (See Tables 3.3 and 3.4). The standardized MMD scores were considered to be significant at the 0.05 probability level, when their value was greater than 2.0 (See Table 3.4) (Sofaer 1986:270).

Problems with Collection of Data

As with many archaeological samples, some of the skeletal material was heavily damaged. This damage was not only a result of age, but was also caused by poor preservation techniques. Some of the material was stored in plastic bags or in damp conditions which can cause skeletal material to mildew. Many of the skulls were placed in cardboard boxes without any packing materials to prevent damage when the skulls were moved. Due to the general methods of skeletal analysis at the time of the collection of this material, very little of the postcranial skeletal remains were preserved at all. If they were preserved, they were frequently not identified with a particular cranium. This is the main reason why I did not examine non-metric traits on postcranial bones. Much of the Beaker material in was collected in the late 19th and early 20th centuries, and had been preserved and 'repaired' according to the approved methods of the time. In a number of cases this involved coating the skulls with resin or glue in the interests of preservation. After 100 or more years in conditions of varying humidity, the resin tends to peel off the skulls,

obscuring or destroying a number of non-metric traits. A number of the skulls were also reconstructed using plaster. This was done for the purpose of the metrical analysis which was extremely popular in the late 19th and early 20th centuries. This plaster 'repair' work often obscured large parts of the surface of the skull, thereby concealing a number of non-metric traits. These problems decreased the amount of data I was able to collect and led to a number of missing values.

Skeletal Samples Used in Study:

The majority of the skulls used in this study were originally excavated and collected in the mid to late 19th and early 20th centuries, prior to the development of radiocarbon dating. As a result, they were generally identified and dated by their archaeological context, stratigraphy, associated artifacts and mortuary practices.

As mentioned in chapter 1, a number of the skulls were collected by well-known archaeologists of the day, such as Lord Pitt-Rivers, John Thurman and EJH Schuster. As a result they were studied and analysed according to the highest standards of the late 19th and early 20th Centuries. Reports giving the details of the archaeological excavations and stratigraphy were prepared and published. These reports generally contained illustrated descriptions of associated artifacts, as well as the archaeological context and the skeletal remains found. As a result of the intense interest in metrical analysis at the time (See Chapter 2 for more details), many of the skulls and some post-cranial bones were measured and drawn (later photographed), in an effort to establish the population to which

they belonged.

Other skeletal material used in this study was collected and analysed by various local amateur archaeological societies, such as the Wiltshire Archaeological Society. These societies were generally affiliated with a local museum and worked to excavate and catalogue sites in their region. Members of these societies would undertake these excavations themselves, or would sponsor others to do so. Reports were prepared on the findings of these excavations and presented before the society and sometimes published in local journals. These reports contain details and illustrations of the excavations, archaeological contexts, associated artifacts and skeletal remains and are reputable archaeological sources for the time.

The materials I used in this study were held at the following museums: The British Museum of Natural History in London, The Duckworth Collection at Cambridge University, The Hull City Museum, Sheffield Public Museum, Wells City Museum, The Devizes Museum and The Salisbury Museum. Those I classified as 'Southern' all came from counties located in southern England: Dorset, Gloucesteshire, Northhamptonshire, Kent and Wiltshire. The 'Northern' materials came from the counties of Derbyshire, Staffordshire and Yorkshire. I made this division for the purpose of creating contemporary populations made up of samples which were relatively close to each other. A number of the samples within these divisions are widely separated (up to 60 miles). Given the extremely sparse samples available in these time periods (Early Neolithic and Early Bronze Age), however, I felt this to be the only possible method of population comparison.

Within the categories of Northern and Southern, I compared Early Neolithic to Early

Bronze Age. I would have preferred to compare populations over a smaller time range, such as Late Neolithic to Early Bronze Age, but this was not possible as there was very little identified Late Neolithic skeletal material in the areas containing Early Bronze Age, Beaker material. All the non-metric observations were performed by myself, and not taken from secondary sources.

Details of the individual skeletons used in this study, the museums they are held in, their associated artifacts, descriptions of their mortuary style and their references are given in Appendix A.

Population Samples and Locations

As mentioned previously, this study makes use of non-metric analysis (See Appendix B for trait descriptions), in looking at the question of possible population change in the Neolithic/Bronze Age transition. While non-metric analysis has been widely used in various archaeological problems involving questions of population change in prehistory, it has not been a major research tool in looking at the so-called 'Beaker Problem' in Britain. This is in large part due to the lack of popularity of non-metric analysis in Britain.

In this study four populations separated by location and time are compared (see Table 2.3 below), for descriptions of skeletal material and associated artifacts see Appendix A. The majority of the skeletons used for this study were male, see Table 2.4 for sex distribution among the different population samples.

Population A: a population composed of samples taken from locations in the north of England from the Early Neolithic time period.

Locations and Sample sizes:

Yorkshire: Dinnington (11), Ebberston (2), Rudstone (2)
Staffordshire: Long Low (1)

Population B: a population composed of samples taken from locations in the north of England from the Early Bronze time period. These samples were associated with 'Beaker' vessels.

Locations and Sample sizes:

Yorkshire: Acklam Wold (1), Hanging Grimston (1), Garrowby Wold (1), Garton Slack (5), Towthorpe (1), Weaverthorpe (1), Rudstone (1)
Derbyshire: Green Low (1), Castern (1), Bee Low (1), Stakor Hill (1), Blake Low (1), Haddon Field (1), Monsal Dale (1), Mouse Low (1)

Population C: a population composed of samples taken from locations in the south of England from the Early Neolithic time period.

Locations and Sample sizes:

Dorset: Handley (4)
Gloucestershire: Belas Knap (5), Nympsfield (1), Rodmarton (2)
Kent: Coldrum (1)
Somerset: Chewton Mendip (1)
Wiltshire: West Kennet (8), Lan Hill (3), Norton Bavant (4), Lugbury (2), Heytesbury (2), Fussell's Lodge (1)

Population D: a population composed of samples taken from locations in the south of England from the Early Bronze time period. These samples were associated with 'Beaker' vessels.

Locations and Sample sizes:

Dorset: Gibb's Walk (1), Handley (2), Easton Down (1), Chrichel Down (1), Dorchester (1)
Northhamptonshire: Aldwincle (2)
Somerset: Chewton Plain (2)
Wiltshire: Stonehenge (1), Amesbury (2), Roundway (1)

Table 2.3: Sample Location and Size

Site Location	Total (n)
Northern: Early Neolithic (A)	16
Northern: Early Bronze Age (B)	19
Southern: Early Neolithic (C)	34
Southern: Early Bronze Age (D)	14
Total:	83

Table 2.4 Sex Distribution of Skeletons:

Site Location	Male (n)	Female (n)	Total (n)
Northern: Early Neolithic (A)	10	6	16
Northern: Early Bronze Age (B)	13	6	19
Southern: Early Neolithic (C)	23	11	34
Southern: Early Bronze Age (D)	13	1	14
Total:	59	24	83

Chapter Three

Results

Introduction to Results

The bilateral traits in the study which did not display significance for sex or side were summed for the purpose for MMD analysis (See Table 3.1). The number of individuals per population which expressed a given trait are given in Table 3.2. Table 3.3 gives the MMD scores for each population and the standard deviations of the MMD scores for each population.

Table 3.1 The sides each trait was observed on, are summed per sample by region. The traits not used in the MMD analysis, due to sex significance are marked (**), the trait not used due to 0% incidence is marked (*).

	North Neolithic	%	North Bronze Age	%	South Neolithic	%	South Bronze Age	%
Accessory Infraorbital Foramen	4/16	25.0	6/20	30.0	5/23	21.7	7/20	35.0
Accessory Mental Foramen	0/4	0.0	2/26	7.6	6/31	19.4	3/26	11.5
Auditory Torus	0/21	0.0	0/33	0.0	1/46	2.2	2/26	7.7
Bregmatic Ossicle	0/15	0.0	0/18	0.0	0/34	0.0	2/14	14.3
Condylar Facet Double	4/16	25.0	5/19	26.3	9/32	28.1	11/21	52.4
Condylar Foramen	0/14	0.0	2/11	18.2	3/24	12.5	1/16	6.3
Coronal Ossicles**	19/29	65.5	28/36	77.8	41/66	62.1	19/27	70.4
Ethmoidal Foramen	2/24	8.3	1/14	7.1	4/34	11.8	2/18	11.1
Frontal Foramen	8/23	34.8	16/32	50.0	22/49	44.9	10/27	37.0
Frontal Grooves**	10/27	37.0	6/37	16.2	13/66	19.7	2/27	7.4
Highest Nuchal Line	31/31	100.0	27/32	84.4	61/67	91.0	25/26	96.2
Inferior Squamous Foramen	0/18	0.0	0/19	0.0	1/40	2.5	2/21	9.5
Infraorbital Suture	1/15	6.7	1/9	11.1	1/21	4.8	0/18	0.0
Lateral Supraorbital Foramen	0/31	0.0	4/37	10.8	21/63	3.2	2/28	7.1
Marginal Tubercle**	3/16	18.8	2/30	6.6	4/29	13.8	3/21	14.3
Mastoid Foramen**	17/22	77.3	20/27	74.1	42/56	75.0	24/26	92.3
Maxillary Torus	4/14	28.6	3/36	8.3	2/29	6.9	8/28	28.6
Metopism	10/27	37.0	12/28	42.8	4/37	10.8	0/14	0.0
Nasal Foramen	7/9	77.8	10/13	76.9	12/19	63.2	7/11	63.6
Ossicle at Asterion	6/22	27.3	6/28	21.4	11/53	20.8	5/25	20.0
Ossicle at Lambda	4/16	25.0	3/16	18.8	4/31	12.9	3/14	21.4
Occipital Foramen	5/20	25.0	5/21	23.8	6/53	11.3	4/24	16.7
Occipitomastoid Ossicle	3/22	13.6	4/27	14.8	8/54	14.8	5/26	19.2
Parietal Foramen	18/32	56.3	14/33	42.4	27/63	42.9	14/26	53.8
Parietal Notch Bone	4/22	18.2	4/28	14.3	10/54	18.5	5/25	20.0
Patent Premaxillary Suture*	0/8	0.0	0/17	0.0	0/17	0.0	0/14	0.0
Posterior Condylar Canal Patent	8/16	50.0	6/11	54.5	10/22	45.5	7/20	35.0
Precondylar Tubercle	1/9	11.1	1/13	7.6	3/16	18.8	2/10	20.0
Rocker Jaw	0/2	0.0	1/13	7.6	3/14	21.4	4/13	30.8
Squamomastoid Suture	6/19	31.6	6/27	22.2	15/54	27.8	3/26	11.5
Squamous Ossicle**	4/18	22.2	0/16	0.0	7/43	16.3	7/23	30.4
Supraorbital Foramen Complete	5/32	15.6	8/37	21.6	9/62	14.5	4/28	14.3
Supranasal Suture	10/16	62.5	12/18	66.6	26/33	78.8	11/14	78.6
Supratrochlear Notch	2/32	6.3	2/30	6.6	9/66	13.6	3/28	10.7
Sutura Mendosa	15/20	75.0	8/20	40.0	21/56	37.5	9/26	34.6
Sutural Foramen	5/21	23.8	11/24	45.8	19/54	35.2	8/27	29.6
Trochlear Spurs	1/30	3.3	7/28	25.0	7/65	10.8	3/28	10.7
Zygomatico-Facial Foramen**	12/16	75.0	16/28	61.5	23/34	67.6	16/25	64.0
Zygomaxillary Tubercle**	0/12	0.0	3/29	10.3	3/28	10.7	2/21	9.5

The traits which did not display significance for either sex or side and were used in the MMD analysis are listed below:

1. Accessory Infraorbital Foramen
2. Accessory Mental Foramen
3. Auditory Torus
4. Bregmatic Ossicle
5. Condylar Facet Double
6. Condylar Foramen
7. Ethmoidal Foramen
8. Frontal Foramen
9 Highest Nuchal Line
10. Inferior Squamous Foramen
11. Infraorbital Suture
12. Lateral Supraorbital Foramen
13. Maxillary Torus
14. Metopism
15. Nasal Foramen
16. Occipitomastoid Ossicle
17. Ossicle at Asterion
18. Ossicle at Lambda
19. Occipital Foramen
20. Parietal Foramen
21. Parietal Notch Bone
22. Posterior Condylar Canal Patent
23. Precondylar Tubercle
24. Rocker Jaw
25. Squamomastoid Suture
26. Supraorbital Foramen Complete
27. Supranasal Suture
28. Supratrochlear Notch
29. Sutura Mendosa
30. Sutural Foramen
31. Trochlear Spurs

Table 3.2 The number of individuals per sample by region that expressed traits. Traits not used in MMD analysis, due to sex significance are marked (**), the trait not used due to 0% incidence is marked (*).

Traits	North Neolithic	%	North Bronze Age	%	South Neolithic	%	South Bronze Age	%
Accessory Infraorbital Foramen	4/16	25.0	5/19	26.3	4/34	11.8	6/14	42.9
Accessory Mental Foramen	0/16	0.0	2/19	10.5	4/34	11.8	2/14	14.3
Auditory Torus	0/16	0.0	0/19	0.0	1/34	2.9	1/14	7.1
Bregmatic Ossicle	0/16	0.0	0/19	0.0	0/34	0.0	2/14	14.3
Condylar Facet Double	3/16	18.8	4/19	21.1	8/34	23.5	7/14	50.0
Condylar Foramen	0/16	0.0	2/19	10.5	3/34	8.8	1/14	7.1
Coronal Ossicles**	12/16	75.0	17/19	89.5	25/34	73.5	11/14	78.6
Ethmoidal Foramen	2/16	12.5	1/19	5.3	3/34	8.8	2/14	14.3
Frontal Foramen	10/16	62.5	9/19	47.4	18/34	52.9	6/14	42.9
Frontal Grooves**	8/16	50.0	4/19	21.1	10/34	29.4	2/14	14.3
Highest Nuchal Line	16/16	100.0	16/19	84.2	32/34	94.1	13/14	92.9
Inferior Squamous Foramen	0/16	0.0	0/19	0.0	1/34	2.9	2/14	14.3
Infraorbital suture	1/16	6.3	1/19	5.3	1/34	2.9	0/14	0.0
Lateral Supraorbital Foramen	0/16	0.0	4/19	21.1	2/34	5.9	2/14	14.3
Marginal Tubercle**	2/16	12.5	2/19	10.5	4/34	11.8	2/14	14.3
Mastoid Foramen**	12/16	75.0	14/19	73.7	26/34	76.5	13/14	92.9
Maxillary Torus	3/16	18.8	2/19	10.5	1/34	2.9	5/14	35.7
Metopism	8/16	50.0	12/19	63.2	4/34	11.8	0/14	0.0
Nasal Foramen	7/16	43.8	10/19	52.6	12/34	35.3	7/14	50.0
Ossicle at Asterion	5/16	31.3	5/19	26.3	10/34	29.4	4/14	28.6
Ossicle at Lambda	4/16	25.0	3/19	15.8	4/34	11.8	3/14	21.4
Occipital Foramen	4/16	25.0	4/19	21.1	4/34	11.8	4/14	28.6
Occipitomastoid Ossicle	3/16	18.8	3/19	15.8	8/34	23.5	4/14	28.6
Parietal Foramen	12/16	75.0	13/19	68.4	21/34	61.8	9/14	64.3
Parietal Notch Bone	4/16	25.0	4/19	21.1	9/34	26.5	4/14	28.6
Patent Premaxillary Suture*	0/16	0.0	0/19	0.0	0/34	0.0	0/14	0.0
Posterior Condylar Canal Patent	5/16	31.3	4/19	21.1	6/34	17.6	5/14	35.7
Precondylar Tubercle	1/16	6.3	1/19	5.3	3/34	8.8	2/14	14.3
Rocker Jaw	0/16	0.0	1/19	5.3	3/34	8.8	4/14	28.6
Squamomastoid Suture	4/16	25.0	4/19	21.1	9/34	26.5	2/14	14.3
Squamous Ossicle**	4/16	25.0	0/19	0.0	6/34	17.6	5/14	35.7
Supraorbital Foramen Complete	4/16	25.0	8/19	42.1	7/34	20.6	3/14	21.4
Supranasal Suture	10/16	62.5	12/19	63.2	26/34	76.5	11/14	78.6
Supratrochlear Notch	1/16	6.3	2/19	10.5	7/34	20.6	3/14	21.4
Sutura Mendosa	9/16	56.3	7/19	36.8	14/34	41.2	6/14	42.9
Sutural Foramen	5/16	31.3	9/19	47.4	17/34	50.0	5/14	35.7
Trochlear Spurs	1/16	6.3	5/19	26.3	6/34	17.6	2/14	14.3
Zygomatico-Facial Foramen**	7/16	43.8	12/19	63.2	16/34	47.1	10/14	71.4
Zygomaxillary Tubercle**	0/16	0.0	2/19	10.5	2/34	5.9	2/14	14.3

Biological Distance :

The MMD equation was performed using the remaining 31 traits which did not display significance in terms of sex or side difference. Given the small sample sizes involved and the apparent lack of significance for those traits remaining, the sexes were pooled and the sides summed for bilateral traits.

Table 3.3

The raw MMD scores are in the lower triangle, and the standard deviations of MMD scores in the upper triangle.

	North Neolithic	North Bronze Age	South Neolithic	South Bronze Age
North Neolithic		0.0474	0.0311	0.0630
North Bronze Age	0.6457		0.0252	0.0544
South Neolithic	6.9557	5.5503		0.0369
South Bronze Age	0.5268	0.4813	6.9024	

Table 3.4

The standardized MMD scores, derived through dividing the raw MMD scores by their standard deviations.

	North Neolithic	North Bronze Age	South Neolithic	South Bronze Age
North Neolithic				
North Bronze Age	13.6224			
South Neolithic	223.6559	220.2500		
South Bronze Age	8.3619	8.8474	187.0569	

Discussion of MMD Analysis

The assessment of MMD scores has been approached in different ways by various researchers. A number of researchers have used a threshold method for determining sigificance, i.e. the MMD is considered statistically significant when it is equal to or greater than twice its standard deviation (Sjovold 1973; Thoma 1981:305).

As mentioned earlier, this study makes use of the methods reccommended by Sofaer (1986), as the population comparison is based on uneven sample sizes. According to Sofaer's method of determining significance (standardized MMD scores greater than 2.0), all of these populations displayed significant differences, and therefore significant biological distance from one another. However, it is clear from the results of both the raw and standardized MMD scores, that Population C (Southern Early Neolithic) displayed the greatest distance from all the other Populations compared. This raises the question of possible population replacement or significant admixture in terms of all the Populations analysed, but most especially Population C. The findings of this study do suggest population change over time in the Northern and Southern regions compared. This study also shows differing degrees of change, in that Population C appeared to be the most distinct from all other groups. This greater degree of difference is partially caused by Population C being larger in relation to Populations A, B and D. This, however, only accounts for some of the difference. This study indicates that further research, on the British Southern Early Neolithic inhabitants in particular is worthwhile. One potential study would be non-metric trait frequency comparison of British Southern Neolithic samples to contemporary Neolithic European mainland populations.

Chapter Four

Discussion and Conclusion

Discussion

Beginning in the late 19th and early 20th centuries, the earliest analyzes and interpretations of the Beaker remains in Britain relied on the concept of movement. These assumptions were based on the idea that the apparent cultural change at the time of the Neolithic- Bronze Age transition could only have resulted from the influence of an innovative, culturally and technologically 'superior' migrant population. Many of the Beaker graves coming to light throughout central and western Europe in the late 19th and early 20th centuries were dated as early Bronze Age- a time of marked cultural change (Harrison 1980).

These graves contained supposed ritual items such as copper and bronze knives and ornaments- products of advanced metallurgical practices, tanged and barbed arrowheads, stone wristguards and highly worked ornaments and jewellery of amber, sheet gold and jet (Harrison 1980:9). They also contained the remains of an apparently physically distinct people; taller, more robust and brachycephalic, unlike their supposed indigenous contemporaries- a dolichocephalic people (Harrison 1980:160; Brodie 1994).

This combined evidence of a physically distinct people, with superior metal-working skills, different mortuary practices and a new, intrusive ceramic style (the highly

decorated and distinctive Bell Beaker vessels), was used to validate the concept of migration as the cause of cultural innovation and change (Case 1977; Mercer 1977; Harrison 1980; Brodie 1994).

This was a reflection of late 19th and early 20th century archaeological theory which tended to view any major cultural change as resulting only from "a shock from without" (Childe 1950:10). Much emphasis was placed on the migratory origins of the Beakers, and many theories based on their supposed origins and patterns of movement were put forward. These ranged from the suggestion that the Beakers were a nomadic pastoral people, whose superior copper-working skills enabled them to rapidly spread throughout Europe (Castillo 1928; Burgess 1976), to the suggestion that the Beakers could be viewed as armed traders, establishing trade routes throughout Europe (Childe 1950). Various points of origin were suggested for the Beakers, such as Egypt, the Orient, Central Europe and Spain (Harrison 1980).

All of the early theories on Beaker origins placed an emphasis on movement, in part to explain the lack of associated archaeological materials, such as dwelling types, standard farming methods and other evidence of common daily living practices (Harrison 1980; Brodie 1994). Later theories were based less on the assumption of migration and actual population change, as on the idea of cultural diffusion. It was suggested, for example, that the Beaker 'cultural package' could have spread throughout Europe in association with the spread of a cult based on the believed contents of the Beaker vessels: alcohol (Burgess 1976; Sherratt 1987). The most recent interpretations of Beaker remains, based on the concept of cultural diffusion, suggest the trade of Beaker vessels and associated artifacts

as prestige items (Brodie 1994). In this way, the interpretations of Beaker archaeological remains have changed to reflect the trends in archaeological theory from the time of their first discovery up to the present.

Underlying the so-called 'Beaker Problem', however, is the recurring question in archaeology- is the apparent cultural change found in the archaeological record evidence of population replacement or continuity? Because of this fundamental issue, the field of physical anthropology has been used in the analysis of Beaker skeletal remains from early on in their discovery.

Early physical anthropological studies were based on a simple cranial index, a ratio of skull length to width. A change in this index from long-headed (dolichocephalic) to broad-headed (brachycephalic) was seen as adequate proof of population distinctiveness or change (Harrison 1980; Brodie 1994; Gould 1996). Later research undertaken by Franz Boas, found skull shape, i.e. cranial index, to be much more 'plastic' then earlier researchers had found (Boas 1949). The fact that bone development is susceptible to environmental influences was established by Boas and confirmed by later researchers. One such researcher was Neil Brodie (1994), whose work on the 'Beaker Problem' was based on the cranial index.

Neil Brodie addressed the 'Beaker Problem' in his study based on metrical analysis (1994).His findings regarding the question of population change and the possibility of the external origin of a distinct Beaker culture, were inconclusive. He, like earlier researchers, observed that the Beakers had a different 'skull type' than earlier Neolithic populations. The Beakers were clearly brachycephalic, while the Neolithic were dolichocephalic

(Brodie 1994:71). This, however, does not necessarily indicate the arrival of a migrant population. The Beakers appear to be reflective of a general trend towards brachycephaly which began developing around 3000 BC (Brodie 1994:79).

Brodie and other researchers have suggested that changes in environment, both climatic and cultural, could affect bone development and therefore change the Cranial Index. In terms of climate, Brodie and other researchers found that: Cranial Index does seem to correlate positively with temperature and negatively with humidity (Brodie 1994:74). Brodie correlated studies of climate change in Britain with prehistoric Cranial Index change over time. He found that there was evidence of a period of more unsettled weather from 4240 cal BC to 3800 cal BC. During this period, the climate appeared to have been more variable, as well as wetter and colder. Brodie speculated that Neolithic cranial morphology was influenced by these cold, damp conditions. In contrast, during the early Bronze Age (2480 cal BC- 1450 cal BC), the climate was apparently drier. Brodie argues that as a result, the gradual increase in the Cranial Index which occurred in north-western Europe during the Neolithic and early Bronze Age could have been in response to climatic improvement (Brodie 1994:77-78).

Brodie also suggested that cultural environment may have had a significant impact on bone development in British Neolithic populations. These British populations were extremely dolichocephalic even in relation to their contemporaries on the European mainland (Brodie 1994:78). Brodie suggested that this extreme dolichocephaly may have resulted from the posterior enlargement of the temporales muscles. He speculated that this reflected the possibility that the Neolithic inhabitants of Britain tended to use their teeth

for various tasks, for which their continental contemporaries used tools (Brodie 1994:78).

In this way, Brodie suggested that environmental influences, both climatic and cultural could have been the underlying causes for the change in Cranial Index over time. His study did not, however, definitively show that the Beakers were either a distinct migrant population or an indigenous population. He acknowledged that the craniometric data he analyzed in his study were open to two possible interpretations:

1) That the appearance of the brachycephalic skull announces the arrival of an immigrant population.

2) That the different skull morphologies are caused by different cultural or climatic environments.

(Brodie 1994:78).

Brodie's study does not definitively confirm either population replacement or continuity. Brodie himself was of the opinion that the change in the Cranial Index was caused by environmental factors, and that there had not been an influx of a distinct Beaker population. He admitted the limitations of his study however:

> The biological literature suggests that morphological change might occur in response to parallel changes in the extra-cranial environment and be partly independent, at least, of any genetically-driven microevolutionary process. The results of this cranial study and consideration of comparative material do not contradict this suggestion. However, this should not be taken as confirmation of the non-existence of the "Beaker Folk". Rather, it serves to emphasise that the brachycephalisation of prehistoric Britons was a biological phenomenon, and one which cannot be utilised for the investigation of an archaeological entity such as the Beaker culture (Brodie 1994:80)

Brodie's study serves to illustrate the limitations of a study based solely on metrical analysis. My own study, based on non-metrical analysis is also highly problematic, in the

face of small sample sizes and damaged skeletal material. Given the little skeletal material available, I 'created' four populations for the purpose of comparison: Population A (Northern Neolithic), B (Northern Bronze Age), C (Southern Neolithic) and D (Southern Bronze Age). I compared Populations A and B and Populations C and D, in order to see if there was significant population change over time in the same general geographic area. I also compared Populations A and C and Populations B and D to see if these comparisons would display population change. I had assumed that A and C and B and D would be likely to show population change, as they were geographically distant from one another.

My findings and the statistical analyses are displayed in tables 3.3 and 3.4. In fact all of the population comparisons displayed statistical significance indicating population change. As a result, this study could be used to refute the contention that the Beakers were not necessarily a distinct, migrant population. According to this view, the cultural innovations appearing at the beginning of the Bronze Age, was well as the Beaker 'cultural package', found in the grave sites dating from this period, could have resulted from cultural diffusion. The most widely accepted theory of cultural diffusion applied to the 'Beaker Problem', is that of the 'Beaker' vessels being prestige items.

This view is based on the supposed concentration of wealth into the hands of a few individuals as a result of the stratification of society. This stratification, was supposed to have begun to take place at the end of the Neolithic and the beginning of the Bronze Age. As a result, the Beaker vessels and accompanying ritual items were seen as status symbols acquired and traded by the upper levels of society (Harrison 1980:15; Brodie 1994:5). Therefore trade contact, rather than migration or invasion could be seen as the vector for

cultural change and the appearance of new and intrusive technologies and cultural items.

The findings of this study do suggest population change over time in both the Northern and Southern regions compared, and as a result, could be used to support the claim that the Beakers were a distinct and migratory population in Britain.

Conclusion

The statistical analysis and comparison of the Northern populations (A and B), and the Southern populations (C and D) , did reveal significant differences. This would appear to support the theory that the 'Beakers' may have been a distinct migratory population, and that the movement of Beaker vessels and associated items was not simply the result of cultural diffusion, through the trade of status items (Harrison 1980; Brodie 1994).

The findings in my study are questionable due to the small sample sizes, and the poor state of preservation of much of this material. I also found that these traits varied in terms of their usefulness for the purpose of determining biological distance for these populations, further study to establish which traits are most indicative of population would be worthwhile.

Alternative Methods of Study

I do not believe that this or previous studies definitively answers the question of replacement or continuity in terms of the so-called 'Beaker Problem'. As a result, I would suggest that studies based on other methods or approaches to this question would be worthwhile.

A study based on mitochondrial genetic analysis could be highly effective. This method of analysis is developing rapidly and growing in popularity. It has been used in a number of questions on population change. It is a growing field, as more effective techniques for extraction of mtDNA from ancient bone are being developed (Brown 1992; Hagelberg 1991 and 1993; Goldman 1992; Richards et.al. 1993). One example of this type of analysis, is a study recently undertaken by Martin Richards et. al (1996). This study examined 821 individuals from Europe and the Middle East in an attempt to establish population origins and patterns of movement and origins in prehistoric Europe. This study proved to be highly effective in answering questions of replacement vs. continuity, they were able to conclude that

> ....ancestors of the great majority of modern, extant lineages entered Europe during the Upper Paleolithic. A further set of lineages arrived from the Middle East much later, and their age and geographic distribution within Europe correlates well with archaeological evidence for two culturally and geographically distinct Neolithic colonization events that are associated with the spread of agriculture. It follows from this interpretation that the major extant lineages throughout Europe predate the Neolithic expansion and that the spread of agriculture was a substantially indigenous development accompanied by only a relatively minor component of contemporary Middle Eastern agriculturalists (Richards et.al. 1996:185).

While mitochondrial DNA studies are also problematic, in that the 'calibration' of a mtDNA 'clock' is still controversial (Richards et. al. 1996), this study serves to demonstrate the great potential of this type of analysis and its future applications to questions of population change.

A study based on mtDNA analysis could be problematic in addressing this question due to the damaged state of much of this skeletal material. As mentioned earlier many of these samples do not include post cranial bones. Post cranial bones, such as segments from long bones (femur or humerus bones) are often used for mtDNA extraction (Hagelberg et.al. 1991:400-401). As it is, the crania are often all that remain of these skeletons. If there is an attempt to extract mtDNA from this cranial material, a potential issue is that of DNA contamination.

This is due in part to the poor preservation techniques used on these crania. As mentioned earlier, many of these skulls were 'repaired' with plaster. Many others were re-assembled or entirely coated with glue. This is a potential problem in mtDNA analysis, as the DNA contained the glue (an animal product) could contaminate the mtDNA extracted from the preserved bone. The risk of contamination is always a serious potential problem in ancient DNA studies (Richards et al. 1993:19-20). Given the advances presently being made in the extraction of DNA from ancient bone, however, this method of analysis may well be of use in the future.

Alternative Cranial Non-metrical Studies and Future Directions

The method of non-metrical analysis is also potentially useful in other approaches to the same question. One possibility is that of comparing contemporary Bronze Age populations. Those skeletal remains with associated Beaker vessels and accompanying so-called Beaker 'ritual items' to Bronze Age skeletons without such associated artifacts. If the 'Beakers' are an intrusive, migrant population, they should display significant difference from their Bronze Age contemporaries.

Another possibility is in attempting to establish the point of origin of this supposed migrant population. It has been shown that the earliest Beaker vessels originated in the Netherlands (Lanting and van der Waals 1972). It has also been shown that the earliest Beaker vessels found in Britain greatly resemble these Dutch vessels (Clark 1966; Harrison 1980).

If the Beakers were in fact a migrant population originating in the Netherlands and traveling to Britain, bringing their ceramic style with them, a study based on cranial non-metrical analysis comparing contemporary Dutch and British early Bronze Age populations would be worthwhile.

Appendix A

EN- Early Neolithic

BB- Bell Beaker

S- Southern

N- Northern

Museum Abbreviations:

Cambridge: Duckworth Collection at Cambridge University
Devizes: The Devizes Museum
Hull: Hull City Museum
London: British Museum of Natural History
Salisbury: Salisbury Museum
Sheffield: Sheffield Public Museum
Wells: Wells City Museum

Sites

1. Handley: Multiple inhumation deposit in long barrow, male skull (Pitt-Rivers IV, 1898:66). skeleton 3. Salisbury Museum. Group: EN; S (Brodie 1994:93).

2. Handley: Multiple inhumation deposit in long barrow, male skull (Pitt-Rivers IV, 1898:66). skeleton 4. Salisbury Museum. Group: EN; S (Brodie 1994:93).

3. Handley: Multiple inhumation deposit in long barrow, male skull (Pitt-Rivers IV, 1898:66). skeleton 5. Salisbury Museum. Group: EN; S (Brodie 1994:93).

4. Handley: Contracted male inhumation in ditch deposits of long barrow with leaf shaped flint arrowhead in ribs (Pitt-Rivers IV, 1898:63). skeleton 8; Green 201. Salisbury Museum. Group: EN; S (Brodie 1994:93).

5. Stonehenge: Male skull, two leaf-shape arrowheads in ribs, single non-ceremonial burial, excavated 1978. Skull 7 (English Heritage, Archaeological Report 10, 1995). London. Salisbury Museum. Group: BB; S.

6. Gibb's Walk: (Handley, Rushmore) Contracted male inhumation in grave under round barrow with Beaker (Pitt-Rivers II, 1898:5). Salisbury. Group: BB; S (Brodie 1994:93).

7. Handley: Contracted male inhumation in grave in long barrow mound with Beaker. (Pitt-Rivers IV, 1898:114; Clarke 1970: 191) FN. Salisbury Museum. Group: BB; S (Brodie 1994:93).

8. Handley: Contracted male inhumation in grave under round barrow with Beaker. (Pitt-Rivers II, 1898:5). Salisbury Museum. Group: BB; S (Brodie 1994:93).

9. Easton Down: Male skull with Beaker. Burial 4,124 (Pitt-Rivers II 1898). Salisbury Museum. Group: BB; S.

10. Acklam Wold: Contracted male inhumation in grave under round barrow with flint dagger, flint knife, v-bored amber button, pyrites, bone pin, jet ring and Beaker. 40yrs burial 4 (Clarke 1970:91). S1. (Wright 1905). Hull Museum. Group: BB; N (Brodie 1994:96).

11. Hanging Grimston: Contracted female inhumation in grave under round barrow with Beaker. 40yrs (Clarke 1970:99). burial 3. (Wright 1905). Hull Museum. Group: BB; N (Brodie 1994:100).

12. Garrowby Wold: Contracted male inhumation in grave under round barrow with Beaker and piece of flint. 40yrs, burial 2 (Clarke 1970:135) S2. (Wright, 1904). Hull Museum. Group: BB; N (Brodie 1994:98).

13. Garton Slack: Contracted male inhumation in grave under round barrow with Beaker, bronze pricker and seven flint flakes, burial 3; (Clarke 1970:1215). N3. Hull Museum 96. Group: BB; N (Brodie 1994:99).

14. Garton Slack: Contracted male inhumation in grave under round barrow with Beaker, bone pin, polished flint axe, flint knife and three flint flakes. 40 yrs p. 215, burial 2; N3 (Clarke 1970:1305; Wright 1903). Hull Museum. Group: BB; N (Brodie 1994:99).

15. Garton Slack: Contracted male inhumation in grave under round barrow with Beaker and flint knife. 40 yrs, burial 1, grave B; (Clarke 1970:214; Wright 1903) N3. Hull Museum. Group: BB; N (Brodie 1994:99).

16. Garton Slack: Contracted male inhumation in grave under round barrow with Beaker. 40 yrs p.223, burial 3; (Clarke 1970:223; Wright 1903) S1. Hull Museum. Group: BB; N (Brodie 1994:98).

17. Garton Slack: Contracted male inhumation in grave under round barrow with Beaker, flint dagger, perforated stone battle-axe and v-bored jet button. 40 yrs p.209, burial 6; (Brewster 1980:92; Clarke 1970: 1296; Roe 1966: 261; Wright 1903) S1. Hull Museum. Group: BB; N (Brodie 1994:98).

18. Towthorpe: Contracted female inhumation in grave under round barrow with Beaker.40 yrs, bottom of grave S2 (Clarke 1970:12). Hull Museum 65. Group: BB; N (Brodie 1994:101).

19. Chewton Plain: Male skull with Beaker, grave under round barrow c.1800BC. Burial A. (Somerset Archaeological Society 1947-1950 vol. 93-95:39-67). Wells Museum. Group: BB; S.

20. Chewton Plain: Female skull with Beaker, grave under round barrow c.1800BC. Burial B. (Somerset Archaeological Society 1947-1950 vol. 93-95:39-67). Wells Museum. Group: BB; S.

21. Chewton Mendip: Male skull, this skull together with two others was discovered in a tumulus at Chewton Mendip, Somerset, was accompanied by Neolithic ceramic bowl (museum notes). Burial East 2. (Somerset Archaeological Society 1947-1950 vol. 93-95:39-67). Wells Museum. Group: EN; S.

22. Roundway: Contracted male inhumation in grave under round barrow with Beaker, flint barbed and tanged arrowhead, tanged copper dagger, bracer and bronze pin. (Wiltshire Archaeological Magazine, 3 1857:186; Clarke 1970: 1135; Gerloff 1975; Green 1980:206; Davis and Thurman 1865:142). Group: BB; S (Brodie 1994:95).

23. Amesbury: Contracted male inhumation in round barrow mound with Beaker, bronze awl, antler slip, flint scraper and wooden objects. (Wiltshire Archaeological Magazine, 70/71 1978:14; Clarke 1979:1037) S2(E). burial A; Cambridge Eu 1.4.100. Group: BB; S (Brodie 1994: 94).

24. Amesbury: Contracted male inhumation in ditch under round mound with Beaker. (Wiltshire Archaeological Magazine, 70/71 1978:16; Clarke 1970:1036). burial B Cambridge Eu 1.4.101. Group: BB;S (Brodie 1994:94).

25. Aldwincle: Disarticulated male inhumation under round barrow with Beaker, probably Clarke Type S3. (Northhamptonshire Archaeology, 11 1976:30). Cambridge Eu 1.4.97. Group: BB; S (Brodie 1994: 94).

26. Aldwincle: Male inhumation under round barrow with Beaker. Cambridge Eu 1.5.98. (Thurman 1867:55).Group: BB; S.

27. West Kennet: Multiple inhumation deposit in chambered tomb, male skull. (Thurman 1867:55; Davis and Thurman 1865:150). burial 4, Cambridge Eu 1.5.64. Group: EN; S (Brodie 1994: 94).

28. West Kennet: Multiple inhumation in north-east chamber of chambered tomb, female skull. (Piggott 1962:25) burial 1. Cambridge Eu 1.5.142. Group: EN; S (Brodie 1994:95).

29. West Kennet: Multiple inhumation in south-west chamber of chambered tomb, female skull (Piggott 1962:26) skull 1. Cambridge Eu 1.5.147. Group: EN; S (Brodie 1994:95).

30. West Kennet: Multiple inhumation in south-west chamber of chambered tomb, female skull (Piggott 1962:26) skull 3. Cambridge Eu 1.5.149. Group: EN; S (Brodie 1994:95).

31. West Kennet: Multiple inhumation in north-west chamber of chambered tomb, male skull (Piggott 1962:26) skull 1. Cambridge Eu 1.5.150. Group: EN; S (Brodie 1994:95).

32. West Kennet: Multiple inhumation deposit in chambered tomb, male skull (Thurman 1867: 55) burial 1.Cambridge Eu 1.5.61. Group: EN; S (Brodie 1994:94).

33. West Kennet: Multiple inhumation deposit in chambered tomb, male skull (Thurman 1867: 55) burial 2.Cambridge Eu 1.5.62. Group: EN; S (Brodie 1994:94).

34. West Kennet: Multiple inhumation deposit in chambered tomb, male skull (Thurman 1867: 55) burial 13.Cambridge Eu 1.5.63. Group: EN; S (Brodie 1994:94).

35. Lan Hill: Multiple inhumation deposit in chambered tomb, male skull. (Proceedings of the Prehistoric Society, 4 1938:125) burial 1. Cambridge Eu 1.5.104. Group: EN; S (Brodie 1994:95).

36. Chrichel Down: Contracted male inhumation in grave under bowl barrow with Beaker and flint flake (Archaeologia 90, 1944:75; Clarke 1970:201; Proceedings of the Prehistoric Society 1940:131). Cambridge Eu 1.4.57. Group: BB; S (Brodie 1994:93).

37. Lan Hill: Multiple inhumation deposit in chambered tomb, female skull (Proceedings of the Prehistoric Society, 41938:125) burial 2. Cambridge Eu 1.5.105. Group: EN; S (Brodie 1994:95).

38. Lan Hill: Multiple inhumation deposit in chambered tomb, female skull (Proceedings of the Prehistoric Society, 4 1938:125) burial 5. Cambridge Eu 1.5.107. Group: EN; S (Brodie 1994:95).

39. Norton Bavant: Multiple inhumation deposit in long barrow, male skull (Thurman 1867: 55). Cambridge Eu 1.5.92. Group: EN; S (Brodie 1994:95).

40. Norton Bavant: Multiple inhumation deposit in long barrow, male skull (Thurman 1867: 55). Cambridge Eu 1.5.93. Group: EN; S (Brodie 1994:95).

41. Norton Bavant: Multiple inhumation deposit in long barrow, female skull (Thurman 1867: 55). Cambridge Eu 1.5.98. Group: EN; S (Brodie 1994:95).

42. Norton Bavant: Multiple inhumation deposit in long barrow, female skull (Thurman 1867: 55). Cambridge Eu 1.5.99. Group: EN; S (Brodie 1994:95).

43. Coldrum: Multiple inhumation deposit in chambered tomb, male skull. (Journal of the Royal Anthropological Institute, 43 1913:78). Cambridge Eu 1.5.118. Group: EN; S (Brodie 1994:94).

44. Belasknap: Multiple inhumation deposit in chambered tomb, male skull (Proceedings of the Society of Antiquaries 3 1866:277) burial CIII. Cambridge Eu 1.5.5. Group: EN; S (Brodie 1994:93).

45. Belasknap: Multiple inhumation deposit in chambered tomb, female skull. (Proceedings of the Society of Antiquaries 3 1866:277) burial DII. Cambridge Eu 1.5.3. Group: EN; S (Brodie 1994:93).

46. Belasknap: Multiple inhumation deposit in chambered tomb, male skull (Proceedings of the Society of Antiquaries 3 1866:277) burial CV. Cambridge Eu 1.5.6. Group: EN; S (Brodie 1994:93).

47. Belasknap: Multiple inhumation deposit in chambered tomb, female skull (Proceedings of the Society of Antiquaries 3 1866: 277) burial CVI. Cambridge Eu 1.5.7. Group: EN; S (Brodie 1994:93).

48. Belasknap: Multiple inhumation deposit in chambered tomb, male skull (Proceedings of the Society of Antiquaries 3 1866:277) burial DIV. Cambridge Eu 1.5.10. Group: EN; S (Brodie 1994:93).

49. Lugbury: Multiple inhumation deposit in chambered tomb, male skull (Grinsell 1957: 142). Cambridge Eu 1.5.53. Group: EN; S (Brodie 1994:95).

50. Lugbury: Multiple inhumation deposit in chambered tomb, female skull (Grinsell 1957: 142). Cambridge Eu 1.5.59. Group: EN; S (Brodie 1994:95).

51. Heytesbury: Multiple inhumation deposit in long barrow, male skull (Thurman 1865:473). Cambridge Eu. 1.5.79. Group: EN; S (Brodie 1994:95).

52. Heytesbury: Multiple inhumation deposit in long barrow, male skull (Thurman 1865:473). Cambridge Eu. 1.5.80. Group: EN; S (Brodie 1994:95).

53. Nymphsfield: Multiple inhumation deposit in chambered tomb, male skull (Thurman 1863-4: 55). Cambridge Eu 1.5.65. Group: EN; S (Brodie 1994:93).

54. Rodmarton: Multiple inhumation deposit in chambered tomb, male skull (Thurman 1863-4:55). Cambridge Eu 1.5.68. Group: EN; S (Brodie 1994:93).

55. Weaverthorpe: Contracted male inhumation on old ground surface under round barrow with Beaker (Greenwell 1877:193; Clarke 1970:1403; Schuster 1905-6:127). London SK1921. Group: BB; N (Brodie 1994:101)

56. Rudston: Contracted female inhumation in grave under round barrow with Beaker and antler pick (Greenwell 1877:231; Clarke 1970:1366; Schuster 1905-6:156). London SK1950. Group: BB; N (Brodie 1994:101).

57. Dinnington: Multiple inhumation deposit in long barrow, male skull (Thurman 1863-4:132; Schuster 1905-6:22). London SK1814. Group: EN; N (Brodie 1994:97).

58. Dinnington: Multiple inhumation deposit in long barrow, female skull. JT p.132. (Schuster 1905-6:24). London SK1815. Group: EN; N (Brodie 1994:97).

59. Dinnington: Multiple inhumation deposit in long barrow, male skull (Thurman 1863-4: 132; Schuster 1905-6:25). London SK1816. Group: EN; N (Brodie 1994:97).

60. Dinnington: Multiple inhumation deposit in long barrow, female skull (Thurman 1863-4:132 and 478; Schuster 1905-6:26). London SK1817. Group: EN; N (Brodie 1994:97).

61. Dinnington: Multiple inhumation deposit in long barrow, male skull (Thurman 1863-4:132). London SK1807. Group: EN; N (Brodie 1994:96).

62. Dinnington: Multiple inhumation deposit in long barrow, female skull (Thurman 1863-4:132). London SK1809. Group: EN; N (Brodie 1994:97).

63. Dinnington: Multiple inhumation deposit in long barrow, male skull (Thurman 1863-4:132; Schuster 1905-6:21). London SK1813. Group: EN; N (Brodie 1994:96).

64. Dinnington: Multiple inhumation deposit in long barrow, female skull (Thurman 1863-4:132 and 478; Schuster 1905-6:27). London SK1818. Group: EN; N (Brodie 1994:97).

65. Dinnington: Multiple inhumation deposit in long barrow, female skull (Thurman 1863-4:132; Schuster 1905-6:28). London SK1819. Group: EN; N (Brodie 1994:97).

66. Dinnington: Multiple inhumation deposit in long barrow, male skull (Thurman 1863-4:132; Schuster 1905-6:29). London SK1820. Group: EN; N (Brodie 1994:97).

67. Dinnington: Multiple inhumation deposit in long barrow, female skull (Thurman 1863-4:132; Schuster 1905-6:30). London SK1821. Group: EN; N (Brodie 1994:97).

68. Dorchester: Museum documentation records that this male skeleton was found with a Beaker in its hands close to the Hospital Gates, Dorchester. It is possibly Dorchester G5, recovered when lowering the floor of the Masonic Hall, with a Beaker in the arm of the skeleton. London SK26. Group: BB; S (Brodie 1994:93).

69. Ebberston: Multiple inhumation/cremation deposit in long barrow, male skull (Greenwell 1877:486; Schuster 1905-6:4). London SK1795. Group: EN; N (Brodie 1994:97).

70. Ebberston: Multiple inhumation/cremation deposit in long barrow, male skull (Greenwell 1877:486; Schuster 1905-6:7). London SK1798. Group: EN; N (Brodie 1994:97).

71. Rudston: Multiple inhumation/cremation deposit in long barrow, male skull. (Greenwell 1877:501; Rolleston 1877:613; Schuster 1905-6:19). London SK1803. Group: EN; N (Brodie 1994:101).

72. Rodmarton: Multiple inhumation deposit in chambered tomb, female skull (Thurman 1863-4:55; Davis and Thurman 1865:159, Schuster 1905-6:39). London 1823 Group: EN; S (Brodie 1994:93).

73. Fussell's Lodge: Multiple inhumation deposit in long barrow, probably female skull. (Archaeologia, 100 1957: 1-80). London SK3312. Group: EN; S (Brodie 1994:95).

74. Rudston: Multiple inhumation/cremation deposit in long barrow, male skull (Greenwell 1877:501) London SK1802. Group: EN; N (Brodie 1994:101).

75. Green Low: Contracted male inhumation in cist under round barrow with Beaker, 3 flint barb and tanged arrowheads, flint dagger, 3 bone spatulae and bone awl (Bateman 1861: 53 and 59; Clarke 1970:115; Green 1980:131. Bateman p.53; Davis and Thurman 1865:141). Sheffield J93.909. Group: BB; N (Brodie 1994:92).

76. Castern: Contracted male inhumation in cist under round barrow with Beaker. (Clarke 1970:835; Bateman 1848:84 and 87) Sheffield J93.915. Group: BB; N (Brodie 1994:94).

77. Long Low: Multiple inhumation deposit in cist in long cairn with two flint leaf arrowheads and a flint knife, male skull (Bateman 1861:145-146; Green 1980:130; Davis and Thurman 1865:133). Sheffield J93.930. Group: EN; N (Brodie 1994:94).

78. Bee Low: Contracted female inhumation in grave under round barrow with Beaker and serrated flint blade (Bateman 1861:72 and 177; Clarke 1970:153). Sheffield J93.935. Group: BB; N (Brodie 1994:92).

79. Stakor Hill: Contracted female inhumation in grave under round barrow with Beaker. Bateman 1861:80 and 192; Clarke 1970:122). Sheffield J93.922. Group: BB; N (Brodie 1994:93).

80. Blake Low: Contracted female inhumation in grave under round barrow with Beaker. Bateman 1861:41 and 112; Clarke 1970:135). Sheffield J93.941. Group: BB; N (Brodie 1994:92).

81. Haddon Field: Male skull. Skull J93-914 (Catalogue of Antiquities at Lomberdale House 1855; Catalogue of the Bateman Collection of Antiquities in the Sheffield Public Museum 1899: 159-171). Group: BB; N.

82. Monsal Dale: Disembodied female skull in grave under round barrow close to Beaker. Bateman 1861:76 and 181; Clarke 1970:143). Sheffield J93.943. Group: BB; N (Brodie 1994:92).

83. Mouse Low: Male skull with Beaker. Skull J93-943 (Catalogue of Antiquities at Lomberdale House 1855; Catalogue of the Bateman Collection of Antiquities in the Sheffield Public Museum 1899:159-171). Group: BB; N.

Appendix B

Trait descriptions

1. Accessory infraorbital foramina: A second foramen may lie immediately adjacent to the infraorbital foramen (Berry and Berry 1967:370).

2. Accessory Mental foramina: On the external surface of the mandible inferior to the premolar region, there is usually a foramen. Occasionally there may be one or more additional foramina (Hauser and De Stefano 1989:231).

3. Auditory torus: Rarely a bony ridge or torus is found on the floor of the external auditory meatus (Berry and Berry 1967:368).

4. Bregmatic ossicle: A sutural bone (the bregmatic or interfrontal) may occur at the junction of the sagittal suture with the coronal one (the position of the anterior fontanelle)(Berry and Berry 1967:367).

5. Condylar facet double: Occasionally the articular surface of the occipital condyle is divided into two distinct facets (Berry and Berry 1967:368).

6. Condylar foramina: Behind be occipital condyle there is a depression of variable depth, the condylar fossa. In this fossa frequently exists an aperture which corresponds to the external orifice of the condylar canal. This aperture may vary in size and shape, it may be divided by a thin bony bridge, it may be double, but it may also be absent...Very rarely the condylar canal may open into the hypoglossal canal (Hauser and De Stefano 1989:114-115).

7. Coronal ossicles: Ossicles are sometimes found in the coronal suture (Berry and Berry 1967:367).

8. Ethmoidal foramen exsutural: Two foramina are normally found along the suture between the medial edge of the orbital plate of the frontal bone and the ethmoid bone. Occasionally the anterior foramen is located exsuturally on the orbital plate (Berry and Berry 1967:366; Hauser and De Stefano 1989:61).

9. Frontal foramina: A well-defined accessory notch or foramen may be present immediately lateral to the supraorbital foramen (Berry and Berry 1967:365&367).

10. Frontal grooves: Single or paired grooves may occur and the lateral and external surface of the frontal bone, generally occurring between the frontal eminence and the temporal line (Hauser and De Stefano 1989:61).

11. Highest nuchal line: The inferior and superior nuchal lines form well-marked ridges running horizontally across the occipital bone. A third line (the highest) is sometimes present. It arises with the superior at the external occipital protuberance, and arches anteriorly and laterally, providing attachment for the epicranial eponeurosis. It is more easily felt than seen (Berry and Berry 1967:364).

12. Inferior squamous foramina: Foramen may sometimes occur on the inferior region of the squamous bone (Hauser and De Stefano 1989:29).

13. Infraorbital suture: The infraorbital suture is the continuation of the infraorbital canal on to the external surface of the maxilla. The suture may continue inferiorly to the infraorbital foramen, or end before reaching the foramen (Hauser and De Stefano 1989:61&68).

14. Lambdoid ossicle(s): One or more ossicles may occur in the lambdoid suture. Up to about twelve distinct bones may be present on either side (Berry and Berry 1967:366). Not used in MMD analysis.

15. Lateral supraorbital foramina: The supraorbital margin of the orbit is formed entirely by the frontal bone, which in this region may show either notches or foramina in varying positions and numbers and of varying sizes (Hauser and De Stefano 1989:51). In this case, the foramen may occur on the lateral regions of the supraorbital margin.

16. Marginal tubercle: A bony projection of variable size may occur on the zygomatic bone, at the temporal border of the frontal process (Hauser and De Stefano 1989:228-229).

17. Mastoid foramina: When present, the mastoid foramen usually lies in the suture between the mastoid part of the temporal bone and the occipital bone. Less frequently it lies exsuturally, piercing the mastoid part of the temporal bone, or, more rarely, the occipital bone (Berry and Berry 1967:368).

18. Maxillary torus: The maxillary torus is a bony ridge running along the lingual aspects of the roots of the molar teeth (Berry and Berry 1976:369).

19. Metopism: The medio-frontal suture disappears within the first two years of life. In a few individuals it persists throughout life: this condition is known as metopism (Berry and Berry 1967:367).

20. Nasal foramina: Between the frontal processes of the maxilla the two nasal bones are inserted... Near its centre there are usually the apertures of two canals which pierce the nasal bone, sometimes there are more than one aperture in each of the nasal bones (Hauser and De Stefano 1989:66).

21. Occipital foramina: One or more foramina may be present in the occipitomastoid suture. Sometimes these foramina will be located on the occipital bone near the occipitomastoid suture (Hauser and De Stefano 1989:203).

22. Occipitomastoid ossicle: Ossicles situated in the occipitomastoid suture (Hauser and De Stefano 1989:196).

23. Ossicle at asterion: The junction of the posterior inferior angle of the parietal bone with the occipital bone and the mastoid portions of the temporal bone is known as the asterion. A sutural bone may occur at this junction (Berry and Berry 1967:368).

24. Ossicle at lambda: A bone may occur at the junction of the sagittal and lambdoid sutures (the position of the posterior fontanelle) (Berry and Berry 1967:365).

25. Parietal foramina: This pierces the parietal bone near the sagittal suture a few centimetres in front of the lambda. It transmits a small emissary vein, and sometimes a small branch of the occipital artery (Berry and Berry 1967:366).

26. Parietal notch bone: The parietal notch is that part of the parietal bone that protrudes between the squamous and the mastoid portions of the temporal bone. It may form a separate ossicle which is known as the parietal notch bone (Berry and Berry 1967:368).

27. Patent premaxillary suture: This suture may appear on the anterior area of the palate, crossing the palatal suture (Hauser and De Stefano 1989:168).

28. Posterior condylar canal patent: The posterior condylar canal usually pierces the condylar fossa which lies immediately posterior to the occipital condyle. Sometimes it ends blindly in the bone, and has only been scored as patent when a seeker can be passed through it. Scoring this character is unsatisfactory in skulls in poor condition because the bone of the condylar fossa is often fragile, so that a patent canal and a broken fossa are indistinguishable (Berry and Berry 1967:368).

29. Precondylar tubercle: Occasionally a bony tubercle lies immediately anterior and medial to the occipital condyle. A centrally placed tubercle has been regarded as two fused tubercles (Berry and Berry 1967:368).

30. Rocker Jaw: Rocker jaw is due to a pronounced curvature on the inferior surface of the horizontal ramus of the mandible (Prowse 1994:62).

31. Sagittal ossicles: One or more ossicles may be present along the sagittal suture (Brothwell 1981:94). Not used in MMD analysis.

32. Squamomastoid suture: The posterior part of the mastoid process and its rounded apex are roughened by muscle insertions. The anterior part neighbouring the external auditory meatus has a smooth surface. The junction between those two areas corresponds to that between the petrous part of the temporal bone posteriorly and the squamous part anteriorly. The suture separating the two parts- the sutura squamomastoidea- may persist in the adult either partially or locally (Hauser and De Stefano 1989:206).

33. Squamous ossicle: Ossicles may occur in the curved suture between the temporal squama and the parietal bone. Single or multiple squamous ossicles of different sizes and shapes may be either at one spt only or along the whole suture (Hauser and De Stefano 1989:220).

34. Supraorbital foramen complete: The supraorbital foramen transmits the supraorbital vessels and nerve. It is frequently incomplete (or open). In this case it is often described as a 'supraorbital notch (Berry and Berry 1967:369).

35. Supranasal suture: In the majority of juvenile and adult skulls there is a short complex zig-zag median suture in the glabellar region. This supranasal suture does not represent the nasal part of a metopic suture which is generally of a simple pattern. In the adult, the supranasal suture consists of bony spicules interlocking with each other from the right and the left sides and leading to transverse elaborate structures after fusion (Hauser and De Stefano 1989:44).

36. Supratrochlear notch: The supraorbital margin of the orbit is formed entirely by the frontal bone, which in this region may show either notches or foramina in varying positions and numbers of varying sizes (Hauser and De Stefano 1989:51). In this case, there may be a notch in the trochlear region of the orbit.

37. Sutura mendosa: (Biasterionic suture) A suture may occur on the lateral margins of the occipital squama, originating at the junction of the mastoid portion of the temporal bone, and the parietal and occipital bones (Hauser and De Stefano 1989:195).

38. Sutural foramina: There may be one or more foramina present in the occipitomastoid suture. These are scored as present or absent, if there is more than one present, the number is recorded (Berry and Berry 1967:364; Hauser and De Stefano 1989:203).

39. Trochlear spur: Small spur which projects from the medial wall of the orbit just behind the superomedial angle of the orbit just behind the superomedial angle of the orbital margin. It results from the ossification of one of the two ligaments which connect the cartilaginous trochlear to the frontal bone (Hauser and De Stefano 1989:62-64).

40. Zygomatic arch suture: There is variability in the pattern of the sutures and the degree of division of the zygomatic bone (Brothwell 1981:46). The Zygomatic arch suture trait was not used in the MMD analysis due to flawed data collection

41. Zygomatico-facial foramina: This is a small foramen which pierces the zygomatic bone opposite the junction of the infraorbital and lateral margins of the orbit. It transmits a nerve and small artery, and may be single, multiple or absent (Berry and Berry 1967:369).

42. Zygomaxillary tubercle: In the region of inferior border of the zygomatico-maxillary suture an inferiorly projecting tubercle of variable size is sometimes present (Hauser and De Stefano 1989:211&228).

References

Adams, W.Y.
1968 Invasion, Diffusion, Evolution? Antiquity XLII: 194-214.

Ambercromby, J.
1912 Bronze Age Pottery, I. Oxford: Oxford University Press.

Anderson, J.E.
1968 Skeletal "anomolies" as genetic indicators. In: The Skeletal Biology of Earlier Human Populations. D.R. Brothwell, ed. Pergamon, Oxford, pp.135-147.

Anthony, D.W.
1990 Migration in Archaeology: The Baby and the Bathwater. American Anthropologist, 92:895-914.

Arnold, D.E.
1985 Ceramic Theory and Cultural Process. Cambridge: Cambridge University Press.

Bateman, T.
1848 Vestiges of the Antiquities of Derbyshire. London.

Bateman, T.
1861 Ten Years' digging in Celtic and Saxon Grave Hills in the counties of Derby, Stafford and York from 1848 to 1858. London.

Berry, A.C. and R.J. Berry
1967 Epigenetic variation in the human cranium. Journal of Anatomy 101:361-379.

Binford, L.R.
1962 Archaeology as Anthropology. American Antiquity 28:217-225.

Boas, F.
1949 Race, Language and Culture. Columbia University. New York: The Macmillan Company.

Bohannan, P. and M. Glazer, (editors)
1988 High Points in Anthropology. New York: McGraw-Hill Inc.

Bradley, R.
1984 The Social Foundations of Prehistoric Britain. London: Longman.

Brewster, T.C.M.
1980 The Excavation of Garton and Wetwang Slacks. London: R.C.H.M.

Brewster, T.C.M.
1984 The Excavation of Whitegrounds Barrow, Burythorpe. Malton, Yorkshire: East Riding Archaeological Research Committee Publications.

Broca, P.
1873 Sur les cranes de la caverne de l'Homme-Mort (Lozere). Revue d'Anthropologie 2:1-53.

Brodie, N.
1994 The Neolithic- Bronze Age Transition in Britain. BAR British Series 238.

Brothwell, D.R.
1981 Digging Up Bones (3rd Edition). London: British Museum of Natural History.

Brown T.A. and K.A. Brown
1992 Ancient DNA and the archaeologist. Antiquity 66:10-23.

Buikstra J.E.
1972 Hopewell in the Lower Illinois River Valley. PhD. dissertation, University of Chicago.

Burl, A.
1987 Stonehenge People. London: Dent.

Burgess, C. and R. Miket (editors)
1976 Settlement and Economy in the Third and Second Millennia B.C. BAR British Series 33, Oxford.

Burgess, C.
1980 The Age of Stonehenge. London: J.M. Dent & Sons Ltd.

Carpenter, J.C.
1976 A Comparative Study of Metric and Non-metric Traits in a Series of Modern Crania, American Journal of Physical Anthropology 45:337-343.

Case, H.J.
1977 The Beaker Culture in Britain and Ireland. in Beakers in Britain and Europe, edited by R. Mercer. BAR series 26.

Castillo, Y.A.
1928 La Cultura del Vaso Campaniforme; Su Origen y Extension en Europa. Barcelona.

Chevrud, J.M., Buikstra, J.E. and Twichell, E.
1979 Relationships between non-metric skeletal traits and cranial size and shape. American Journal of Physical Anthropology 50:191-198.

Childe, V.G.
1929 The Danube in Prehistory. Oxford: Clarendon Press.

1950 Prehistoric Migrations in Europe. Cambridge: Harvard University Press.

Clark, G.
1966 The Invasion Hypothesis in British Archaeology. Antiquity XL 40:172-189.

Clarke, D.L. Beaker Pottery of Great Britain and Ireland. Cambridge:
1970 Cambridge University Press.

Clarke, D.L. (editor)
1972 Models in Archaeology. London: Methuen & Co. Ltd.

Clarke, D.V., T.G. Cowie, A. Foxon, and J.C. Barrett
1985 Symbols of Power at the Time of Stonehenge. Edinburgh: National Museum of Antiquities of Scotland: H.M.S.O.

Cleal, R.M.J., K.E. Walker, R. Montague.
1995 Stonehenge in its landscape, Twentieth Century Excavations. English Heritage, Archaeological Report 10 London: Snoeck- Ducanju and Zoon

Coon, C.
1968 The Origin of Races New York: Alfred A. Knopf.

Corruccini R.S.
1974 An examination of the meaning of cranial discrete traits for human skeletal biological studies. American Journal of Physical Anthropology 40:425-446.

1976 The interaction between non-metric and metric cranial variation. American Journal of Physical Anthropology 44:285-294.

Cunnington, M.E.
1929 Woodhenge. Devizes: Simpsons.

Dahinten S.L. and H.M. Pucciarelli
1983 Effects of protein-calorie malnutrition during suckling and post-waning periods on discontinuous cranial traits in rats. American Journal of Physical Anthropology 60:425-430.

Darwin, C.
1958 (orig.1859) The Origin of Species. New York: New American Library.

Davis, J.B., J. Thurman
1865 Crania Britannica. London: Private Subscription.

De Stefano G.F., Hauser G., Guidotti A., Rossi S., Gualdi Russo E. and Brasili Gualandi
1984 Reflections on interobserver differences in scoring non-metric cranial traits (with practical examples). Journal of Human Evolution 13:153-165.

Finnegan, M.
1978 Non-metric variation of the infracranial skeleton. Journal of Anatomy 125:23-37.

Freeman, M.F. and J.W. Tukey
1950 Transformations related to the angular and square root. Ann. Math. Stat. 21:607-611.

Fu, Y.
1994 Non-metric Study: Jiangzhai Neolithic Population. M.A., Department of Anthropology, University of Alberta.

Garson, J.G.
1893 A Description of the Skeletons Found in How Hill Barrow. Journal of the Anthropological Institute 22:8-20.

Gerloff, S. The Early Bronze Age Daggers in Great Britain. Munich: Prahistorische
1975 Bronzefunde V1/2.

Gibson, A.M.
1982 Beaker Domestic Sites: A study of the domestic pottery of the late third and early second millennia B.C. in the British Isles. BAR British Series 107 (parts i & ii). Oxford.

Goldman N. and N.H. Barton
1992 Genetics and geography. Nature 357: 440-441.

Gould, S.J.
1996 The Mismeasure of Man New York: W.W. Norton & Company.

Green, H.S.
1980 The Flint Arrowheads of the British Isles. Oxford: British Archaeological Reports. British Series 75.

Green, R. and Suchey J.
1976 The use of the inverse sine transformation in the analysis of non-metrical cranial data. American Journal of Physical Anthropology 45:61-68.

Greenwell, W.
1877 British Barrows. London: Oxford University Press.

Grewal, M.S.
1962 The rate of genetic divergence of sublines in the C57BL strain of mice. Genetic research 3:226-237.

Grieder, T.
1975 The interpretation of ancient symbols. American Anthropologist 77:849-55.

Grinsell, L. A List of Wiltshire Barrows, in R.B. Pugh (ed).
1957 A History of Wiltshire: Volume 1. London: Victoria History of the Counties of England.

Grunenberg H.
1963 Pathology of Development. New York: Wiley.

Hagelberg E., L.S. Bell, T. Allen, A. Boyde, S.J. Jones and J.B. Clegg
1991 Analysis of ancient bone DNA: techniques and applications. Philosophical Transactions of the Royal Society of London 333:399-407.

Hagelberg E.
1993 DNA From Archaeological Bone. The Biochemist Aug/Sep.

Hanihara, T.
1992 Dental and Cranial Affinities Among Populations of East Asia and the Pacific: The Basic Populations in East Asia, IV. American Journal of Physical Anthropology 88:163-182.

Harris, M.
1968 The Rise of Anthropological Theory. New York: Thomas Y. Cromwell Inc.

1979 Cultural Materialism. New York: Random House Inc.

Harrison, R.J.
1977 The Bell Beaker Cultures of Spain and Portugal. Bulletin 35, American School of Prehistoric Research. Peabody Museum, Harvard University.

1980 The Beaker Folk. Thames and Hudson Ltd, London.

Hauser G. and G.F. De Stefano
1989 Epigenetic Variants of the Human Skull. Stuttgart: E. Schweizerbart'sche Verlagsbuchhaandlung.

Henschen, Folke
1966 The Human Skull A Cultural History. New York: Frederick A. Praeger, Publishers.

Hershkovitz, I. Ring, B., and Kobyliansky, E.
1990 Efficiency of cranial bilateral measurements in separating human populations. American Journal of Physical Anthropology 83:307-320.

Howells, W.W.
1966 Craniometry and Multivariate Analysis. Papers of the Peabody Museum of Archaeology and Ethnology 57.

1973 Cranial Variation in Man. Papers of the Peabody Museum of Archaeology and Ethnology 67.

1989 Skull Shapes and the Map. Papers of the Peabody Museum of Archaeology and Ethnology 79.

1995 Ethnic Identification of Crania from Measurements. Papers of the Peabody Museum of Archaeology and Ethnology 82.

Irish, J.D. and C.G. Turner
1990 West African dental affinity of Late Pleistocene Nubians Peopling of the Eurafrican-South Asian triangle II. Homo 41:42-53.

Iscan, Mehmet Yasar and Kenneth A.R. Kennedy
1989 Reconstruction of Life from the Skeleton. New York: Alan R. Liss, Inc.

Keita, S.O.Y.
1990 Studies of ancient crania from northern Africa. American Journal of Physical Anthropology 83:35-48.

Kellock, W.L. and P.A. Parsons
1970 A comparison of the incidence of minor non-metrical cranial variants in Australian aborigines with those of Melanesia and Polynesia. American Journal of Physical Anthropology 33:235-240.

Lambrick, G.
1988 The Rollright Stones. London: Historic Buildings and Monuments Commission for England.

Lanting, J.N. and J.D. van der Waals
1972 British Beakers as seen from the Continent, Helinium 12:20-46.

Lee, R.D. (ed.)
1977 Population Patterns in the Past. New York: Academic Press.

Lukacs, J.R. and S.R. Walimbe
1984 Deciduous Dental Morphology and the Biological Affinities of a Late Chalcolithic Skeletal Series from Western India. American Journal of Physical Anthropology 65:23-30.

McLaren, A.
1990 Our Own Master Race: Eugenics in Canada, 1885-1945. Toronto: McClelland and Stewart, Inc.

McGrath, J.W., J.M. Chevrud and J.E. Buikstra
1984 Genetic correlations between sides and heritability of asymmetry for non-metric traits in rhesus macaques on Cayo Santiago. American Journal of Physical Anthropology 64:401-411.

McWilliams, K.R.
1974 Gran Quivira Pueblo and biological distance in the U.S. Southwest. PhD. dissertation, Arizona State University.

Mercer, R. (ed.)
1977 Beakers in Britain and Europe. BAR Supplementary Series 26. Oxford: British Archaeological Reports.

Midgley, M.S.
1992 TRB Culture. Cambridge: University Press.

Molto, J.E.
1979 The assessment and meaning of intraobserver error in population studies based on discontinuous cranial traits. American Journal of Physical Anthropology 51:333-344.

1983 Biological Relationships of Southern Ontario Woodland Peoples: The Evidence of Discontinuous Cranial Morphology. Ottawa: National Museums of Canada, Archaeological Survey of Canada, Paper No. 117.

Morgan, L.H.
1877 Ancient Society. New York: Henry Holt.

Nichol C.R. and C.G.Turner
1986 Intra- and interobserver concordance in classifying dental morphology. American Journal of Physical Anthropology 69:299-315.

Norfolk Archaeological Unit
1982 Beaker Domestic Sites in the Fen Edge and East Anglia. East Anglian Archaeology Report No. 16. Norfolk Museums Service.

Norusis, M.J.
1990 SPSS/PC+ 4.0 Base Manual for the IBM PC/XT/AT and PS/2-SPSS. Statistical Data Analysis. Chicago: SPSS, Inc.

Ossenberg, N.
1969 Discontinuous Morphological Variation in the Human Cranium. PhD. Dissertation, University of Toronto.

1974 Origins and relationships of Woodland peoples: The evidence of cranial morphology. In E. Johnston (ed): Aspects of Great Lakes Anthropology: Papers in Honour of Lloyd A Wilford. St. Paul: Minnesota Historical Society, pp 15-339.

1976 Within and between race distances in population studies based on discrete traits of the human skull. American Journal of Physical Anthropology, 45:701-716.

1977 Congruence of distance matrices based on cranial discrete traits, cranial measurements, and linguistic-geographic criteria in five Alaskan populations. American Journal of Physical Anthropology, 47:93-98.

Piggott, S.
1962 The West Kennett Long Barrow. London: HMSO.

1963 Ambercromby and after: the Beaker Cultures of Britain re-examined, In I. Foster & A. Alcock (eds.), Culture and Environment. London: Routledge Kegan and Paul.

Pitt-Rivers, A.L.F.
1898 Excavations at Cranborne Chase (Volumes I-IV). London: Private Printing.

Pitt-Rivers, G.H.L.F.
1932 Problems of Population. The International Union for the Scientific Investigation of Population Problems. London: Kennikat Press.

Prowse, T.
1994 Biological Affinities of Ancient Egyptians and Nubians. M.A. Department of Anthropology, University of Alberta.

Prowse, T. and N. Lovell
1995 Biological Continuity Between the A- and C-Groups in Lower Nubia: Evidence From Cranial Non-metric Traits. International Journal of Osteoarchaeology 5:103-114.

Reichs, K.J. (editor)
1986 Forensic Osteology: Advances in the Identification of Human Remains. Springfield: Charles C. Thomas Publisher.

Renfrew, C.
1973 Before Civilization: The Radiocarbon Revolution and Prehistoric Europe. London: Cape.

Richards, M. et.al.
1993 Archaeology and genetics: analysing DNA from skeletal remains. World Archaeology 25:18-28.

Richards, M. et.al.
1996 Paleolithic and Neolithic Lineages in the European Mitochondrial Gene Pool. American Journal of Human Genetics 59:185-203.

Robertson-Mackay, M.E.
1980 A 'heads and hoofs' burial beneath a round barrow. Proceedings of the Prehistoric Society 46:123-76.

Roe, F.E.S. The Battle-Axe Series in Britain. Proceedings of the Prehistoric
1966 Society 32:199-245.

Rolleston, G. Descriptions of Figures of Skulls and General Remarks upon the
1877 Series of Neolithic Crania, in W. Greenwell, British Barrows.

Rosing, W.
1984 Discreta of the human skeleton: a critical review. Journal of Human Evolution 13:319-323.

Rouse, I.
1972 An Introduction to Prehistory: A Systematic Approach. New York: McGraw-Hill.

1986 Migrations in Prehistory. Ann Arbor, Michigan: Yale University Press.

Sangmeister, E.
1972 Sozial-okonomische Asepkte der Głockenbecherkultur. Homo: Zeitschrift fur die vergleichende Forschung am Menschen 23:188-203.

Saunders, S. R., Popovich, F. and Thompson, F.
1976 Family studies of non-metric skeletal traits: atlas bridging and clinoid bridging. American Journal of Physical Anthropology 44:203-204.

Saunders, S.R. and Popovich, F.A.
1978a A family study of two skeletal variants: atlas bridging and clinoid bridging. American Journal of Physical Anthropology 49:193-204.

Saunders, S.R.
1978b The Developments and Distribution of Discontinuous Morphological Variation of the Human Infracranial Skeleton. Ottawa: National Museums of Canada, Archaeological Survey of Canada, Paper No 81.

1989 Non-metric skeletal variation. In Reconstruction of Life from the Skeleton (edited by M.Y. Iscan and K.A.R. Kennedy). New York: pp. 95-108 Alan R. Liss, Inc.

Sciulli, P.W.

1990 Cranial metric and discrete trait variation and biological differentiation in the terminal late archaic of Ohio; the Duff Site cemetery. American Journal of Physical Anthropology 88:163-182.

Schuster, E.H.J.

1905-6 The Long Barrow and Round Barrow Skulls in the Collection of the Department of Comparative Anatomy, the Museum, Oxford. Biometrika IV: 351-62

Searle, A.G.

1954 Genetical studies on the skeleton of the mouse: IX. The influence of diet on variation within pure lines. Journal of Genetics 52:413-424.

Shennan, S.J.

1976 Bell Beakers and their context in central Europe. In J.N. Lanting and J.D. van der Waals (eds.), Glockenbeckersymposium Overried 1974. Bussum/Harlem.

Shennan, S.J. (editor)

1989 Archaeological Approaches to Cultural Identity. London: Unwin Hyman Ltd.

Sherratt, A.

1987 Cups that cheered. In W. Waldren and R. Kennard (eds.), Bell Beakers of the Western Mediterranean. Oxford: British Archaeological Reports. International series 331.

Simpson, D.D.A. (editor)

1971 Economy and Settlement in Neolithic and Early Bronze Age Britain and Europe. Leicester University Press.

Sjovold, T.

1977 Non-metrical divergence between skeletal populations. Ossa, 4 (Supplement 1):1-133.

1973 The occurrence of minor non-metric variants in the skeleton and their quantitative treatment for population comparisons. Homo 24:204-233.

1975 Allocation of Single or some few Individuals to one of two or more Groups by Means of Non-metrical Variants in the Skeleton. *Ossa* 2:41-46.

Skelnar, K.
1983 Archaeology in Central Europe: the first 500 Years. New York: Leicester University Press.

Soafer J.A., P. Smith and E. Kaye
1986 Affinities Between Contemporary and Skeletal Jewish and Non-Jewish Groups Based on Tooth Morphology. American Journal of Physical Anthropology 70:265-275.

Sokal, R.R. and H. Uytterschaut
1987 Cranial variation in European populations: a spacial auto correlation study at three time periods. American Journal of Physical Anthropology 74:21-38.

Spencer, H.
1860 The Social Organism. Westminster Review, 17:90-121.

1876 Principles of Sociology. New York: D. Appleton.

Spiegel, M.R.
1992 Theory and Problems of Statistics. London: McGraw-Hill Book Company.

Sterling T.D and S.V. Pollack
1968 Introduction to Statistical Data Processing. New Jersey: Prentice-Hall Inc.

Suchey J.M.
1975 Biological distance of prehistoric central California. Populations derived from non-metrical traits of the cranium. PhD. dissertation, University of California.

Thoma, A.
1981 The pattern of quasi-continuous variation in *Homo sapiens*. Journal of Human Evolution, 10:303-310.

Thurman, J.T.
1863-4 On the Principal Forms of Ancient British and Gaulish Skulls, Part 2. Memoirs of the Anthropological Society of London 1:120-168.

1863-4 On the Principal Forms of Ancient British and Gaulish Skulls, Part 2. Memoirs of the Anthropological Society of London 1:459-519.

1867 Further Researches and Observations on the Two Principal Forms of Ancient British Skulls. Memoirs of the Anthropological Society of London 3:41-80.

1871 On Ancient British Barrows, especially those of Wiltshire and the adjoining Counties (Part II, Round Barrows) Archaeologia 43:285:522.

Thomas, J.
1991 Rethinking the Neolithic. Cambridge: Cambridge University Press.

Torgersen, J.
1951a The developmental genetics and evolutionary meaning of the metopic suture. American Journal of Physical Anthropology 9:193-210.

1951b Hereditary factors in sutural patterns of the skull. Acta Radiologica 36:374-382.

Trigger, B.
1989 A History of Archaeological Thought. Cambridge: Cambridge University Press.

Turner, C.G.
1989 Teeth and Prehistory in Asia. Scientific American, Feb: 88-96

Tylor, E.B.
1871 Primitive Culture. London: J. Murray

Underwood, J.H.
1979 Human Variation and Human Microevolution. Englewood Cliffs: Prentice-Hall Inc.

Utermohle, C. and S.L. Zegura
1982 Intra- and interobserver error in craniometry: a cautionary tale. American Journal of Physical Anthropology 57:303-310

Vine, Philip, M.
1982 The Neolithic and Bronze Age Cultures of the Middle and Upper Trent Basin. British Archaeological Report Series 105, Oxford.

Waldren, W.H. and Rex Claire Kennard (editors)
1987 Bell Beakers of the Western Mediterranean. Parts I & II. The Oxford International Conference. BAR International Series 331 (I & II), Oxford.

Watts, C. & P. Rahtz
1984 Cowlam Wold Barrows. York: Ebor Press.

White, Leslie A.
1945 "Diffusion vs. Evolution": An Anti-Evolution Fallacy. American Anthropologist. 47(3): 339-356.

Whittle, A.
1981 Later Neolithic society in Britain: a realignment. In. C. Ruggles and A.W.R. Whittle (eds.) Astronomy and Society in Britain During the Period 4000-1500 BC, 297-342.

1985 Neolithic Europe A Survey. Cambridge: Cambridge University Press.

Willey, G. R. and Jeremy A. Sabloff
1993 A History of American Archaeology. London: Thames and Hudson Ltd.

Winder, S.
1981 Infracranial nonmetric variation: An assessment of its value for biological distance analysis. PhD. dissertation, Indiana University.

Wright, W.
1904-5 Skulls from Round Barrows of East Yorkshire. Journal of Anatomy and Physiology 38: 119-132; 39: 417-449.